Children's Epistemological Understanding: Developmental Mechanisms and Individual Differences

A Dissertation

SUBMITTED TO THE FACULTY OF

UNIVERSITY OF MINNESOTA

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Advisor: Melissa A. Koenig, PhD

August 2019

Acknowledgements

First and foremost, I would like to thank my research advisor, Melissa Koenig not only for sharing her brilliant insights and talent, but also for her enduring support, mentorship, and belief in me. I would also like to thank my dissertation committee members Maria Sera, Michele Mazzocco, and Panayiota Kendeou, who have always been a source of great knowledge, inspiration, ideas, fruitful challenges and encouragement. As I move forward in my career I continue to hear all four of these incredible mentors and colleagues' their "voices in my head" offering important insight and valuable criticism, and I am a better scientist for it.

A big thank you also goes to Megan Gunnar, for her incredible leadership, support, cheerleading, candor and willingness to let me "pick her brain" about grad school, funding, and professional development. Thank you to Danielle Bordeleau and Lindsey Jendraszak for guiding me through all the hoops and challenges involved in graduate school, and for having done so with such kindness and thoughtfulness.

A big warm thanks goes to my incredible cohort: Sarah Ruiz, Michelle Brown, Jenny Chan, Angela Fenoglio and Jyothi Ramakrishnan. They are truly the best cohort I could have asked for, and some of the best people I know. I continually reap the benefits of their support, wisdom, courage, brilliance and friendship, and am inspired by each of them. For exactly these reasons, I'd also like to thank my unbelievable labmates and "academic sisters" Caitlin Cole, Chelsea Hetherington, Elizabeth Stephens, Katherine Ridge, Annelise Pesch and Pearl Li.

The biggest thank you of all goes to my family. I am so lucky to have my husband Greg Crawford, parents Juan Suárez and Cathy Lees, sister Amanda Suárez, and the

lovely Crawford Clan (Brian, Sue, Matt, Heather and Maddy). I cherish their unconditional love, support, encouragement, and reminders to “stop and smell the roses”.

Finally, I’d like to thank my funders, without whom this work would not be possible: the NAEd/ Spencer Foundation Dissertation Fellowship and the Institution of Child Development Small Grant.

Abstract

Individuals' epistemological understanding—that is, their beliefs about the nature of knowledge and knowing— is thought to have important implications for critical thinking in both formal and informal learning contexts (Burr & Hofer, 2002; Council of Chief State School Officers, 2014; Kuhn, 1999; NGSS Lead States, 2013). Indeed, our epistemological beliefs are thought to influence the questions we ask, the sources of information we place trust in, the certainty of our beliefs, and even academic outcomes (Greene, Sandoval, & Bråten, 2016a). However, most of the literature describes the developmental patterns of epistemological understanding in adolescence and adulthood, without characterizing the cause-effect mechanisms at play, particularly those in childhood. Although there is observational evidence suggesting that parent-child interactions are a context in which epistemological understanding may develop (Luce, Callanan, & Smilovic, 2013), and parent epistemological beliefs have been found to predict children's critical evaluations of speakers who reason about evidence with varying competence (Suárez & Koenig, accepted), the role of adult influences on children's epistemological development has not been examined experimentally. In the present study, I investigate: 1) How children develop the ability to consider the nature of knowledge within the context of conversation; 2) Whether improved epistemological understanding supports children's critical thinking in informal social learning; 3) Whether cognitive self-control and verbal IQ moderate or mediate epistemological development; and 4) Whether individual differences in epistemological understanding relate to parent characteristics.

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Part I: Introduction

What is knowledge? How can we be sure that our knowledge reflects truth? Is truth even knowable? These are just some of the questions that characterize epistemology, or the branch of philosophy focused on understanding the nature of knowledge, how we come to have knowledge, and how we justify or evaluate our knowledge (Steup, 2005). Ancient traditions in epistemology can be traced to western scholars like Plato and Socrates (Goldman, 1986; Plochmann, 1976), as well as to various ancient eastern philosophies including Buddhism, Confucianism and Brahmanism (Ganeri, 2007; Hayes, 2006; Hetherington & Lai, 2012; Tweed & Lehman, 2002).

However, in the 21st century epistemological questions about how to promote discernment between fact from opinion, truth from deception, and dogma from empiricism have dominated our national conversation to such an extent that terms like "alternative facts", "post-truth world" and "fake news" have quickly become a part of our cultural lexicon (Lewandowsky, Ecker, & Cook, 2017). In recent years, age-old epistemological questions about how to promote discernment between fact from opinion, truth from deception, and dogma from empiricism have motivated a call for educators to prioritize developing their students' epistemological understanding (Council of Chief State School Officers, 2014; Kuhn & Shaughnessy, 2018; NGSS Lead States, 2013; Paul, 2017; Rider & Peters, 2018). Why the concern? Individuals' beliefs about knowing and knowledge may have important implications for their day-to-day critical thinking and learning. Specifically, our epistemological views are thought to influence the questions we ask, the sources of information we place trust in, our certainty in what we believe, and so on (Burr & Hofer, 2002; Greene, Cartiff, & Duke, 2018; National Education

Association, 2012). Further compounding these concerns is research pointing to a lack of understanding among the general public about the nature of science, how to reconcile conflicting information, how to critically evaluate sources of information for their reliability, and how to make sense of complex information (Greene & Yu, 2014; Kuhn, 2016; Sinatra, Kienhues, & Hofer, 2014).

In part as a response to these growing concerns, there has been an explosion in research on this topic within the past two decades (Greene et al., 2018; Greene, Sandoval, & Bråten, 2016b). This work has primarily been conducted in various branches of philosophy, psychology, and education, and tends to focus on one of four overarching topics: (1) the developmental trajectory of epistemological understanding; (2) the dimensions of epistemological beliefs; (3) how individual differences in epistemological understanding predict various developmental, academic, and teaching outcomes; and (4) the mechanisms of change underlying epistemological development. All four of these areas of research have played an important role in informing and motivating the current study.

In Part I of this manuscript, I review the literature that motivates and informs the current study. Specifically, in Chapter 1, I discuss the predominant theoretical frameworks on epistemological understanding, drawing particular attention to their major contributions and limitations. In Chapter 2, I offer an overview of developmental research indicating that there are important epistemological developments occurring early in life. In Chapter 3, I discuss individual differences in adolescents' and adults' epistemological understanding, as well as their predictive relation with various academic, social, developmental, and cognitive outcomes. In Chapter 4, I address important theoretical and

methodological questions concerning the mechanisms of epistemological development and the widespread (mis)use of correlational evidence.

Chapter 1: Conceptual and Theoretical Foundations

In this chapter, I discuss the predominant theoretical frameworks on epistemological understanding, drawing particular attention to their major contributions and limitations.

Typology and Terminology. *Prominent Theoretical Frameworks.* I begin first by clarifying pertinent, but potentially confusing, terminology and its relation with certain research traditions and schools of thought. As Greene, et al. (2016a) have noted, the study of personal epistemology is not a single, coherent field. Rather, the fields of philosophy, educational and developmental psychology, and education have all contributed their own discoveries, traditions, terminology, and frameworks to the study of epistemological understanding. These are mutually informative, yet fragmented. This fragmentation is perhaps most evident when we examine the array of terms used to refer to the study of individuals' epistemological understanding: personal epistemology (Burr & Hofer, 2002; Hammer & Elby, 2002), epistemological beliefs (Jehng, Johnson, & Anderson, 1993; Kardash & Scholes, 1996; Kardash & Howell, 2000; Qian & Alvermann, 1995; Schommer, 1990; Schommer, 1998; Schommer, Crouse, & Rhodes, 1992), reflective judgment (King & Kitchener, 2004; KS Kitchener, 1986; KS Kitchener & King, 1981; KS Kitchener, Lynch, Fischer, & Wood, 1993), ways of knowing (Belenky, Clinchy, Goldberger, & Tarule, 1986) (Bang, 2015; Clinchy, 1995), epistemological reflection (Baxter Magolda, 2004), epistemological theories (Hofer & Pintrich, 1997), epistemic beliefs ((Bendixen & Hartley, 2003; Bendixen, Schraw, & Dunkle, 1998a), folk epistemology (R. F. Kitchener, 2002), and epistemological resources (Hammer & Elby, 2002).

For example, the term “personal epistemology”, first originating from Piagetian constructivist traditions (e.g. Kuhn, Cheney, & Weinstock, 2000) but adopted more broadly, approximately refers to the same phenomena that others refer to as “epistemic cognition” (e.g. King & Kitchener, 2004). These terms offer different shades of meaning, reflecting nuanced emphases on individuals’ more general epistemological beliefs, versus the processes by which individuals actively reason about epistemological phenomena (Greene & Yu, 2014; Karen Strohm Kitchener, 1983). Similarly, the terms “naïve epistemology” and “folk epistemology”, most often seen in developmental psychology literature (R. F. Kitchener, 2002; e.g. Montgomery, 1992), fall most closely in line with the term “personal epistemology” in that they typically refer to an individual’s everyday beliefs about epistemological phenomena. It should be noted that I use “epistemological understanding” as an umbrella term referring to epistemological concepts, processes and/or practices.

Existing frameworks can be roughly classified into two groups: developmental models and dimensional models. That is, predominant models tend to focus mostly on either the developmental trajectory or specific features of individuals’ epistemological understanding. However, it should be noted that these models are not mutually exclusive, and indeed there are examples of frameworks that are both. Further complicating matters is that within and across these various frameworks, researchers’ work may be reflective of constructivist approaches, sociocultural approaches, traditions in naturalized epistemology, traditions in social epistemology, and any combination of these. Naturalistic epistemology is an approach to developing theoretical frameworks on epistemic cognition in which adherents have moved away from engaging in a priori

theorizing (Goldman, 1994; R. F. Kitchener, 1993; Kitcher & Schmitt, 1994; Kornblith, 1985; Quine, 1969). Instead, empirical findings from the cognitive and educational sciences drive the conception and development of theories, models, and frameworks. This approach often overlaps substantially with the approach known as social epistemology (Fuller, 2002), or the study of how knowledge is constructed, substantiated, and communicated within and between social groups. For example, a social epistemologist might be interested in studying how the scientific community adheres to specific epistemic practices to make and disseminate knowledge, such as dissertation defenses, reliability coding, or peer review.

Developmental Models. Developmental models of personal epistemology represent some of the earliest and most influential theoretical frameworks on the topic. Along with dimensional models, they dominate the literature and continue to be referenced and utilized in various disciplines of study. Many of these developmental models, particularly the earliest ones, are clearly influenced by Piaget's (1972) stage theory of development, as well as his emphasis on individuals' role in their own knowledge construction, termed "genetic epistemology". Thus, the Neo-Piagetian frameworks reviewed here reflect constructivist views of knowledge as a series of "conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider viable" (von Glasersfeld, 1989, p. 124).

Such is the case with Perry's (1970) classic study of the changes in "intellectual and moral development" among college students. His longitudinal and cross-sectional observations of male Harvard undergraduates focused on how students understand knowledge, how their ideas about "knowing" changed, and the ways in which these

perspectives related to their learning and reasoning more generally. Reminiscent of Piagetian theories of development, Perry proposed that college students' epistemological growth involved passing through an invariable sequence of nine stages. Learners, Perry posited, begin with the view that truth is absolute, and beliefs are either right or wrong. These less sophisticated epistemological views hold that Right or Wrong beliefs are obtained from "Good" or "Bad" authorities. As learners develop, they become increasingly able to recognize that multiple, sometimes conflicting versions of "truth" may simultaneously have at least some degree of legitimacy. This relativist epistemology is particularly sophisticated because it holds that beliefs can be justified with reason, and that as new reasons emerge, epistemic commitments evolve. Thus, according to this framework, epistemological development is characterized by a movement toward relativist viewpoints that are justified by reason rather than authority. Perry's framework became widely popular in part because it speaks to epistemological issues underlying critical thinking, leading many to adopt curricula informed by this framework with the goal of supporting students' critical thinking (Moore, 1994; e.g. Moore, 1981). However, Perry himself clarified that his intent was to produce "a purely descriptive formulation of students' experience," rather than a "prescriptive program intended to 'get' students to develop" (Perry & Chickering, 1981, p. 107). Perry's caution was prudent given the two major limitations in his work: first, that it was developed based on data from non-representative samples; and second, that it focused on the trajectory, rather than the mechanisms, of epistemological development.

Likewise in the Neo-Piagetian vein were Kitchener and King (K.S. Kitchener, 1977; KS Kitchener, 1983; KS Kitchener & King, 1981), who proposed a constructivist

model of epistemic cognition which increasingly reflected traditions in naturalized epistemology over the years (King & KS Kitchener, 2004). Their "reflective judgment model" proposed seven stages of post-adolescent reasoning styles which were summarized into three levels: pre-reflective reasoning (stages 1-3), quasi-reflective reasoning (stages 4 and 5), and reflective reasoning (stages 6 and 7). Pre-reflective reasoning maintains that knowledge is gained through the word of an authority figure or firsthand observation; quasi-reflective reasoning regards knowledge claims as containing elements of uncertainty, and views judgments as idiosyncratic; and reflective reasoning (stages 6 and 7) recognizes that knowledge is actively constructed and re-constructed, contending that claims must be evaluated based on the context, evidence and reasoning processes used to generate them.

Kitchener and King (1981) also posited that epistemic assumptions influence how individuals understand the nature of problems and decide what types of strategies are appropriate for solving them, particularly when facing what John Dewey described as ill-structured problems (1938; 1933). Over 15 years' of cross-sectional and longitudinal research, a 3-level model of cognitive processing was proposed and refined to account for these developments (King & KS Kitchener, 2004; KS Kitchener, 1983). At the first level—cognition—individuals compute, memorize, read, perceive, and solve problems. At the second level—metacognition—individuals monitor their own progress when they are engaged in these first-order tasks. At the third level—epistemic cognition—individuals reflect on the limits, certainty, and conditions of knowing.

Notably, this work is a reaction to Piaget's claims that formal operations are the pinnacle of intellectual development (Inhelder & Piaget, 1958; R.F. Kitchener, 1993).

Although cognitive and metacognitive processes appear to develop in early to middle childhood, research on adult reasoning suggests that epistemic cognitive monitoring develops in the late adolescent and adult years (King & KS Kitchener, 2004; KS Kitchener, 1986; KS Kitchener et al., 1993). Indeed, many Neo-Piagetian researchers have contended that formal operations are an inadequate account of the cognitive abilities of adults (Basseches, 1984; Fischer, 1980; Kuhn, 1989; Richards & Commons, 1990). Despite a firm basis in developmental evidence, the reflective judgment model has not escaped criticism. As Kurfiss (1988) notes, King, KS Kitchener, R.F. Kitchener (e.g. KS Kitchener & King, 1981), and other Neo-Piagetian theorists make deterministic, integrative assumptions of stage models. In contrast Kurfiss (1988) recommends using the terms "position" and "perspective" to describe epistemological judgments. Similarly, Dannefer (1984) notes that developmental theories may fall into the trap of ontogenetic reductionism, or the practice of treating socially produced and patterned phenomena as rooted in the characteristics of the individual organism.

Consequently, Kuhn and colleagues produced their own developmental model of epistemological understanding (Kuhn et al., 2000). Kuhn, an educational psychologist with research interests rooted in the development of informal and scientific reasoning (Kuhn, 1977, 1991; Kuhn & Angelev, 1976; Kuhn, Langer, Kohlberg, & Haan, 1977; Kuhn & Phelps, 1982), also reflects Neo-Piagetian constructivist traditions in a stage-like model of epistemological development. According to this framework, what lies at the heart of mature epistemological understanding is the coordination of the subjective and objective dimensions of knowing. Initially, the objective dimension dominates, and subjectivity is excluded. In this *absolutist* view, assertions are judged to be either right or

wrong, and truth is seen as theoretically knowable. Further, the absolutist learner may see truth as defined by an authority such as scientists, parents, teachers, or even God. Subsequently in development, when *multiplist* perspectives appear, the subjective dimension dominates and the objective is abandoned. In this stage, assertions are judged as neither right nor wrong, and truth is viewed as ultimately unknowable. Finally, the two dimensions of knowledge are coordinated and *evaluativist* judgments are made. In this view, assertions can be evaluated by weighing them against evidence, and through this process truth can be approximated. This way of thinking is most like scientific reasoning.

To be clear, individuals who accept information from an authority are not necessarily reflecting an absolutist perspective. Consider how someone may choose to believe that vaccines do not cause autism after reading a press release from the American Medical Association. An absolutist judgment would involve deeming this as an objective and certain truth, external to the human mind and fixed by authority such as God, WebMD, or the American Medical Association. An evaluativist judgment, on the other hand, would involve believing that vaccinations do not cause autism because thousands of doctors and researchers, fallible as they may be, have collectively deemed it to be true based on years of well-collected evidence and sound reasoning. Thus, absolutists and evaluativists may make similar judgments about what is true, certain, or reliable, but are motivated by different epistemological beliefs and reasoning.

Departing further from Perry's (1970) framework, Kuhn and colleagues (2000) describe how this developmental progression in epistemological perspectives typically occurs in a systematic order across different judgment domains: subjectivity is first and most readily acknowledged in personal taste and aesthetic judgments and least readily in

judgments about the physical world. Once subjectivity is accepted and becomes dominant, objectivity is reintegrated in the reverse order (i.e., most readily with respect to judgments about the physical world and least readily with respect to aesthetic judgments). They also report that for a meaningful subset of individuals, both transitions proved most difficult in the values domain. Kuhn's model also departs from Perry's (1970) because it is based on a sample with a diverse range of educational attainment and domains of expertise. In part because of this diversity, Kuhn and colleagues' (2000) model succeeds in going beyond describing developmental trajectories by suggesting mechanisms of epistemological development: findings indicate that individuals are more likely to develop evaluativist epistemological beliefs over the course of development, particularly in domains of their expertise. That is, in addition to "maturation", Kuhn and colleagues (2000) posit that developing expertise in an area of study is at least one way in which experiences help promote epistemological development.

In more recent years, developmental models influenced by traditions in sociocultural psychology, naturalized epistemology, and social epistemology have emerged. In keeping with Vygotskyan traditions (Vygotsky, 1962, 1978a), these models draw particular attention to the social and cultural processes that contribute to epistemological development, characterizing epistemological beliefs and reasoning as context-dependent. In this view, epistemological beliefs are cultural products and epistemological reasoning is a cultural activity. Sometimes referred to as *epistemological resource models,* these frameworks attempt to account for how contextual factors influence individual knowledge construction, including individuals' ideas about knowledge and knowing (Bendixen & Rule, 2004; Hammer & Elby, 2002; Muis &

Franco, 2009). For example, Chinn and colleagues' (2011) epistemological resource model characterizes twenty-six processes of epistemic cognition based on the epistemic aims that an individual might pursue during a given activity, how those aims relate to non-epistemic aims, and how aims are related to reliable processes of knowledge development. These reliable processes include social practices developed within particular communities to solve specific epistemic problems (Chinn et al., 2011).

Bang and Medin's (2010a) take on epistemological resource models focuses on the ways in which forms of human–nature relations shape the cultural practices that impact knowledge, reasoning, and learning about, in, and with the natural world (Bang, 2015; Lee, 2008; Medin & Bang, 2014b; Rogoff, Paradise, Arauz, Correa-Chávez, & Angelillo, 2003). Bang and Medin (2010a) have broadly referred to this orientation as "relational epistemologies", and seek to characterize the culturally specific ways in which learning unfolds, particularly in the context of outdoor practices. This framework describes various mechanisms by which epistemological understanding can be enculturated throughout development, including family and cultural practices such as nature walks.

Dimensional Models. In addition to developmental models of epistemological understanding, dimensional models are highly popular in the literature. These models focus on characterizing people's views of knowledge and knowing in terms of multiple types of beliefs or theories, which can change independently from one another. Furthermore, unlike most developmental models, which posit that beliefs change in a systematic way, dimensional models tend to hold that epistemological development is less systematic and more variable across individuals.

The arrival of Schommer's (1990) dimensional model represented a major shift in the theoretical conceptualization of personal epistemology. Where developmental models held that epistemological beliefs change in a systematic way (e.g. absolutists hold that knowledge is both simple and externally sourced), Schommer (1990) argued that this might not always be the case (e.g. individuals could hold that beliefs are complex and externally sourced). Schommer's model was comprised of multiple, somewhat independent, belief dimensions on which individuals might vary. Each dimension lies along a continuum representing a degree of epistemological naiveté or sophistication, and more sophisticated beliefs are associated with better performance on academic and learning outcomes. The terms used to refer to dimensions have changed somewhat over time, but are most commonly referred to as simple knowledge, certain knowledge, source of knowledge, ability to learn, and quick learning (Schommer-Aikins, 2004). Some have argued that the ability to learn and quick learning are not truly epistemic in nature, but rather concern beliefs about learning (Greene, Azevedo, & Torney-Purta, 2008; Hofer & Pintrich, 1997; Sandoval, 2009). What is not disputed, however, is that one of Schommer's major contributions to the field was the development of an instrument for measuring epistemic beliefs. Schommer's self-report epistemological questionnaire (EQ), which produced quantifiable scores measuring epistemological sophistication across different dimensions, brought about an explosion of empirical work on epistemic cognition along with different variants of the EQ (e.g. C. A. M. Kardash & Scholes, 1996; Marlene Schommer, 1993; Sinatra, Southerland, McConaughy, & Demastes, 2003). The EQ was developed partly out of an interest in finding links between epistemological understanding and academic outcomes, as we will review in later sections of this paper.

Although Schommer (1990) has been hugely influential in the study of epistemological understanding, it should be noted that this approach is not particularly concerned with the mechanisms by which individual differences in epistemological beliefs develop. Thus, it can be placed squarely in the category of dimensional, rather than developmental, frameworks. This lies in contrast to Hofer and Pintrich's (1997) epistemological theories model, which was born from their efforts to review and find coherence between developmental and dimensional models of epistemic cognition.

Hofer and Pintrich's (1997) epistemological theories model holds that epistemological beliefs are comprised of four somewhat independent dimensions, or "personal theories": simple knowledge, certain knowledge, source of knowledge, and justification of knowledge. They classified the first two dimensions as beliefs about the nature of knowledge, and the latter two as beliefs about the nature of knowing. Borrowing Piagetian terminology, Hofer and Pintrich (1997) posited that change along these dimensions might be due to cognitive disequilibrium, but pointed to models of conceptual change (Posner, Strike, Hewson, & Gertzog, 1982) and sociocultural enculturation (Vygotsky, 1978b) as additional influences for their model of epistemological development. Thus, their effort to postulate mechanisms of epistemological development was not only an attempt to reconcile developmental and dimensional models, but also to syncretize both constructivist and sociocultural traditions in developmental psychology. Another of Hofer and colleagues' major contributions to the field was the insistence that the trajectory of epistemological development be expanded to include younger children, in sharp contrast to most theorists who either posited that epistemological understanding does not emerge until adolescence, or ignored

the question of childhood epistemological understanding altogether (Burr & Hofer, 2002).

Chapter 2: The Development of Epistemological Understanding

As reviewed in Chapter 1, some of the most prominent theoretical models of epistemological understanding focus primarily or entirely on adolescent and adult populations. However, there is an abundance of research on the earliest forms of epistemological understanding from cognitive developmental traditions. In this chapter, I offer an overview of developmental research indicating that there are important epistemological developments occurring early in life. I begin with a review of the research characterizing the socio-cognitive developments that underlie early epistemological understanding. These include "theory of mind", or an awareness of others' minds (Astington, 1993; Carlson, Koenig, & Harms, 2013), and metacognition, which can be broadly defined as cognition about cognition (e.g. thinking about thinking, knowing about knowing, etc.; Flavell, 1979; Papaleontiou-Louca, 2008). Furthermore, I point to existing research that describes how children employ their epistemological understanding to make sense of controversies, evaluate sources of information, and make learning decisions accordingly. Finally, I discuss early epistemological development as it occurs within specific social and cultural contexts.

The Origins of Epistemological Understanding. There is a case to be made that the developmental precursors of epistemological understanding lie in infancy, as evidenced by the early behaviors involved in information exchange. For example, infants are able to follow a person's pointing gesture and check back if there was no obvious target for the point or gaze, suggesting that they attribute knowledge and communicative intent to the pointer (Butterworth, 1991). Moreover, 10- to 13-month old infants from different cultures point towards objects declaratively, and check others' gaze before and

after pointing (Liszkowski, et al., 2004; Callaghan, et al., 2011). Twelve-month-olds will often "answer" an ignorant adult's question about the location of an object with a point (Behne, Liszkowski, Carpenter, & Tomasello, 2012). However, there has been much debate about how to interpret these early gestures, and whether infants recognize the role of attention and perception in knowledge acquisition (Baron-Cohen, 1993; C. Moore, 1996).

Evidence of a dawning epistemological understanding is less ambiguous in toddlerhood. For example, 18-month-olds use the direction of a speaker's points and gaze to infer the referent of a novel word (Baldwin, 1996, 2000), and young 2-year-olds can adjust their requests for assistance based on a person's knowledge state, giving more information to someone who is ignorant of the situation (O'Neill, 1996). Furthermore, infants and preschoolers alike appreciate the effects of informational access on resultant beliefs (Gopnik & Graf, 1988; O'neill, Astington, & Flavell, 1992; O'Neill & Chong, 2001; Onishi & Baillargeon, 2005) (O'neill & Gopnik, 1991; Pillow, 1989; Pratt & Bryant, 1990; H. M. Wellman & Bartsch, 1989; Zaitchik, 1991).

The theory of mind literature thoroughly documents young children's developing understanding of others' mental *states*, such as attention, desire, pretense, imagination, belief, and so on, as they develop within the first 5 years of life (Perner, 1991a; Tomasello, Carpenter, Call, Behne, & Moll, 2005; H. M. Wellman, 2015). For example, 3-year-olds display some awareness of themselves and others as knowers, distinguish thinking about an object from actually perceiving it, and begin to refer to their own knowledge states using verbs such as *think* and *know* (Flavell, 1999). By age 4, they fully differentiate between the non-factive *think* and factive *know* (Dudley, 2018). That is, they

appreciate that the term *know* refers to a belief that is both true and well justified (as opposed to a belief that just happens to be true), whereas *think* needn't be either (for a comprehensive review on young children's concept of knowledge, see Ronfard, Bartz, Cheng, Chen, & Harris, 2017). Four-year-olds can also attribute false beliefs to themselves and others (e.g. Astington, Pelletier, & Homer, 2002; Gopnik & Wellman, 1994; Harris, 1994; Leslie, 1994; Perner, 1991b; B. Wellman & Wortley, 1990). Indeed, the understanding of "false belief", or the ability to make a distinction between what is true and what others believe to be true, is a major developmental milestone in children's epistemological development.

An examination of young children's epistemological understanding in a more naturalistic context provides further evidence of naive epistemological beliefs and reasoning (Walton, 2000). A study of transcripts from spontaneous classroom arguments (grades K-4) revealed that nearly 18% of classroom utterances during class contained epistemological expressions, with the proportion increasing with age (REF?). About one third of the children's epistemological expressions concerned certainty, and contrasted knowledge with belief. Epistemological expressions were used strategically to moderate discussion, but this functioned differently in the talk of children as compared to teachers. Where children used expressions of uncertainty to soften challenges, teachers used the same expressions to make indirect threats and commands. Older children were more likely to discuss cognitive processes (i.e. selective attention) and the veracity of claims (REF?). Thus, not only do individual children have a developing set of epistemological concepts and reasoning skills, but they also employ a shared epistemological understanding to negotiate meaning in everyday interactions.

However, as Koenig (2002) and Wimmer and Gschaider (2000) point out, most research on children's theory of knowledge beyond false belief— including their early-developing notions about the certainty, epistemic source, and justification of belief—has received comparatively less attention. Rather than treating false belief understanding as the crowning achievement of theory of mind development, it has been argued that it precedes another important milestone: the emergence of an interpretive theory of mind (H. M. Wellman, 1992). That is, children begin to appreciate how others' beliefs are actively constructed and subject to bias, misinterpretation, and revision (H. M. Wellman & Hickling, 1994). Along these lines, Gopnik and Meltzoff (2006) maintain that by age 5 years, children understand that a person's beliefs are not faithful and immutable recordings of the world, but rather active interpretations or construals of the world from a given perspective. As Chandler and Lalonde (1998) have noted, an interpretive theory of mind does not automatically emerge as a consequence of false belief understanding (see also Carpendale & Chandler, 1996). Instead, children first develop a "Copy Theory of Mind" whereby the mind is seen as a device that records either faithful or flawed representations of reality. It is the later-developing "Interpretive Theory of Mind" that allows children to recognize and appreciate the human mind's capacity for constructively interpreting (or misinterpreting) reality.

Much of the research on children's interpretive —indeed, constructivist— theory of mind examines developing concepts about their own and others' learning and reasoning processes. For example, between the ages of 3 and 5, preschoolers become increasingly able to articulate how they and others learn: younger preschoolers characterize learning primarily in terms of perceptual access and information-gathering

behaviors, but older preschoolers display an explicit metacognitive understanding of the relations between actions and knowledge-construction (Sobel & Letourneau, 2015, 2018). Despite this, children do not recognize inference as a source of knowledge until about age 6, even if the salience of information justifying a deductive inference is heightened (Keenan, Ruffman, & Olson, 1994; Pillow, 1999; Sodian & Wimmer, 1987). However, by the early school years children appear to recognize and understand various nuanced aspects of other's reasoning and knowledge-construction. For example, school-aged children acknowledge the existence of processes like selective attention, interpretation and various forms of inferential reasoning (Amsterlaw, 2006; Pillow, 2008), and recognize that inferential reasoning results in new or revised epistemic states (Pillow, 1989, 2012; Pillow & Henrichon, 1996).

Sodian, Zaitchik, and Carey (1991) found that 6- and 7-year-old children differentiate hypothetical beliefs from evidence, differentiate between conclusive and inconclusive tests, understand that inferences can be made from the outcome of a conclusive test, and understand that inferences made from inconclusive tests are unwarranted. Furthermore, 6-year-olds seem to value the practical function of reasoning, and judge reasoning as a better way to solve problems than arbitrary methods like flipping a coin (Amsterlaw, 2006). Although 6-year-olds do recognize and appreciate the importance and function of reasoning, their constructivist theory of mind is still developing, particularly with regards to their understanding of the conditions that influence the certainty of knowledge. For example, Pillow and colleagues (2000) found that it is not until fourth grade that children rate conclusions derived from valid inferences as more certain than that those derived from guesses or invalid inferences.

Pillow (2002) also found that only adults differentiated between the certainty of others' deductive and inductive inferences (although it should be noted that adolescents were not studied).

In order to gain a more comprehensive understanding of the development of scientific thinking, Koerber and colleagues (2014) conducted a fascinating cross-sectional study on the development of scientific thinking in elementary school (operationalized as the abilities to engage in experimental design, data interpretation, and understanding the nature of science). Item response theory analyses suggested that the multiple components of scientific thinking develop as a unitary construct independent of children's verbal knowledge and reasoning skills, schooling, and parents' science education.

Children's Epistemological Judgments. Further informing our understanding of epistemological development is research examining children's judgments about specific problems or people. Studies on children's objectivism, or tendency to believe that there is a fixed, objective truth (i.e., what Kuhn, et al. would refer to as "absolutism" 2000), suggest that younger children are more likely than older children to make objectivist judgments. For example, with age children are less likely to say that only one person can be right, and more likely to report that it is acceptable for others to disagree with them (Heiphetz, Spelke, Harris, & Banaji, 2013; Wainryb, Shaw, Langley, Cottam, & Lewis, 2004; Wainryb, Shaw, & Maianu, 1998; Wright, 2012).

Mansfield and Clinchy (2002) conducted a longitudinal study on the development of explicit epistemological judgments in which children were interviewed at ages 10, 13, and 16. They presented children with vignettes in which two characters disagree about issues ranging from immediately resolvable questions of fact to potentially unresolvable

matters of taste or value. The protagonists did not justify their views, and the vignettes did not contain enough information for the children to resolve the issues themselves. Experimenters asked participants a range of questions probing at their epistemological understanding, such as why the protagonists disagreed, who could be right, whether the dispute could be resolved, and (if so) how it could be resolved. Over time, children displayed an increasing awareness of the complexity of both the outer world of objective "reality" and the inner worlds of individual "knowers". Furthermore, they demonstrated an increasingly sophisticated understanding of the ways in which inner and outer worlds intersect in the creation of knowledge. As children developed, their representations of "fact" and "opinion" became less sharply differentiated, and the phenomenon of knowing was understood to be less reactive and more constructive. For example, when asked about whether an unfamiliar animal would make a good pet, a 10-year-old participant indicated that she would need to ask a zookeeper to know the answer. At age 13, the same participant indicated that "there is no right or wrong [answer]" to the question of whether it would make a good or bad pet, because it was a matter of personal taste that cannot really be resolved. By age 16, she had judged the issue to be neither subjective nor objective, but "kind of in the middle". She again recommended asking the zookeeper about whether the animal could be domesticated to determine whether or not it would make a good pet, but also indicated that one must take into account the kind of person who might not need a pet that is fully domesticated.

However, even young children can depart from strictly objectivist judgments. For example, they can differentiate fact from opinion (Banerjee et al., 2007), with children as young as three judging that conflicting claims are more acceptable in the case of opinions

than factual beliefs (Flavell, Flavell, Green, & Moses, 1990). Furthermore, although Kuhn's (2000) work would indicate that young children are inflexibly objectivist in the domain of moral beliefs, findings from Heiphetz and Young (2017) suggest that even preschoolers are capable of nuanced epistemological judgments in the moral domain. Specifically, they found that both preschoolers and adults were more likely to judge that only one person could be right in the case of a widely-held, rather than controversial, moral belief. Therefore, preschoolers view controversial beliefs as more subjective and less fact-like. However, regardless of the scenario, children were more likely than adults to say that only one person could be right in a moral disagreement. Adults were also more likely than children to prefer an individual who shared their controversial moral beliefs (e.g. that it is "ok" to tell a white lie).

Research from the testimonial learning literature provides further insight into children's epistemological development. Specifically, it suggests that children recruit their epistemological understanding to evaluate the reliability of information and its sources, as well as guide their own learning accordingly. Notably, children's understanding *about* other people influences what they choose to learn *from* them, including their decisions to endorse, disbelieve, or remain agnostic about others' claims (Banaji & Gelman, 2013; Heyman, 2008; Mills, 2013; Sobel & Kushnir, 2013; for reviews and discussion, see Stephens, Suarez, & Koenig, 2015). This work reveals that children prefer learning new information from relatively accurate and knowledgeable speakers (Birch, Vauthier, & Bloom, 2008; Einav & Robinson, 2011; M. Koenig & Woodward, 2012; Koenig, Clément, & Harris, 2004; Koenig & Harris, 2005; Pasquini, Corriveau, Koenig, & Harris, 2007; Scofield & Behrend, 2008); privilege informant

reliability over age or familiarity as a cue to guide their novel word learning (Corriveau, Meints, & Harris, 2009; Jaswal & Neely, 2006), prefer to learn from experts (Koenig & Jaswal, 2011; Kushnir, Vredenburgh, & Schneider, 2013; Sabbagh & Baldwin, 2001), and selectively trust informants on the basis of their statement generality and verifiability (Koenig et al., 2015).

This literature also provides ample evidence that children recruit their "interpretive theory of mind" for testimonial learning. That is, preschoolers' evaluations of informants are based on more than their history of accuracy or stated expertise— they also consider the *manner* in which an informant's knowledge is acquired or justified (Koenig & Stephens, 2014). For example, preschoolers forgive an informant's prior inaccuracies if they were due to inadequate perceptual access to information (Brosseau-Liard & Birch, 2011; Nurmsoo, Einav, & Hood, n.d.). Furthermore, preschool-aged readers treat someone with access to print information as reliable, but no longer trust that informant when access to print is removed (Einav & Robinson, 2011). Four-year-olds even distinguish between truly knowledgeable informants and merely accurate informants, seeking novel information from an informant who had previously given answers unaided rather than from an informant who had relied on help from a third party (Einav & Robinson, 2010).

Children also evaluate agents based on certain logical properties of their reasoning. Mercier, Bernard and Clément (2014) found that children as young as 3 favored agents who produced non-circular, rather than circular, arguments for their conclusions (e.g. "The dog went this way because I've seen him go in this direction" vs. "The dog went this way because he went in this direction"). Similarly, Corriveau and

Kurkul (2014) found that 3- and 5-year olds preferred learning novel explanations—and in the case of 5-year-olds, novel labels—from an informant who had previously provided noncircular, rather circular, explanations. Castelain, Bernard, Van der Henst & Mercier (n.d.) even found that 4- to 6-year-olds from traditional Mayan communities recognize an evidence-based argument made by a socially subordinate agent as better than a circular argument made by a dominant agent. Furthermore, Doebel, Rowell and Koenig (Doebel, Rowell, & Koenig, 2016) found that 4- and 5-year-old children judged agent's conceptually inconsistent statements (e.g., "this is both the smallest ball and the largest ball") as 'not making sense;' and by age 5, children selectively learned from logically consistent informants.

In addition to evaluating logical properties of speaker statements, children can evaluate reasoners based their use evidence to draw conclusions. When Koenig (2012) compared speakers who cited good epistemic reasons for their claims (such as prior perceptual access) with to speakers who offered poor reasons (such as desiring, pretending, or guessing something to be true), 3- and 4-year olds not only make appropriate judgments about what counts as a good reason for belief, but also preferentially sought and endorsed information from the informant they had judged to have "the best way of thinking". Subsequently, Suárez and Koenig (accepted) presented children with reasoners who varied in whether they sought readily available information and provided an appropriate justification for their conclusions. The 4-, 5- and 6-year-olds—who were procedurally required to infer or estimate the truth of a speaker's conclusion— attributed knowledge to those who made sound inferences by gathering and citing evidence, and also endorsed their conclusions. In contrast, 6-year-olds, and in some

cases even 5-year-olds, did not systematically attribute knowledge to speakers who made unsound inferences or guesses. Furthermore, 6-year-olds refrained from systematically endorsing the conclusions of poor reasoners. Suárez and Koenig (accepted) also explored individual differences in children's judgments about reasoners who differed in their sensitivity to the strength of statistical evidence. By age 6, children were more likely to indicate that a well-calibrated speaker had "the best way of thinking", rather than a speaker whose predictions were always "very sure", even in the face of ambiguous evidence.

Together, these findings indicate that a naive folk epistemology emerges very early in life. The dawn of epistemological understanding lies in infancy, where children develop an awareness of others' mental states and how they are situated within the world. By preschool, a rudimentary ability to reason about specific features of beliefs (including their truth value, objectivity or subjectivity, and sources) is evident. Furthermore, by the early elementary years children have acquired a constructivist epistemological understanding whereby knowledge is recognized as a product of interpretive cognitive processes, and "good" justifications of beliefs are regarded as those that *ought* to cause belief, including reasons supported by evidence, logic or argument.

Early epistemological development in social and cultural contexts. Just as the foundations of normative epistemological understanding emerge early in life and mature with age, so do individual differences in these beliefs. Developmental findings— including those stemming from sociocultural, naturalized epistemology, testimonial learning, and educational traditions— identify family, social, and cultural contexts as important contributors to individual variations in epistemological understanding.

Family conversation and activity are known to be essential contexts for early cognitive and social development (Ash, 2003; Callanan & Valle, 2008; Ochs, Taylor, Rudolph, & Smith, 1992). Unsurprisingly, they also provide a context within which epistemological development occurs. For example, children's exposure to language influences their theory of mind development: de Rosnay, Pons, Harris and Morrell (2004) examined the contribution of children's linguistic ability and mothers' use of mental-state language to young children's understanding of false belief and their subsequent ability to make belief-based emotion attributions. They found that children who were more linguistically advanced and whose mothers' described them in more mentalistic terms were more likely to understand false belief, indicating that reaching a major milestone in epistemological understanding is supported by parent conversational and linguistic contributions.

When Crowley, Callanan, Jipson, Galco, Topping & Shrager (2001) observed how parents and children co-construct knowledge and theories in museum settings, they found that when children engaged an exhibit with parents, their exploration of evidence was observed to be longer, broader, and more focused on relevant comparisons than children who engaged in the exhibit without their parents. Parents talked to children about how to select and encode appropriate evidence and how to make direct comparisons between the most informative kinds of evidence. Some parents also assumed the role of explainer by casting children's experience in causal terms, connecting their experience to prior knowledge, or introducing relevant abstract principles. Thus, in scaffolding children's ability to collect evidence, interpret it, and use it to construct theories about the causal world, parents also support children's ability to make epistemological judgments about

the origins, justification, and organization of knowledge.

In a review of cross-cultural research on children's social behavior, Mejía-Arauz and colleagues (2018) argue that shared thinking can be conceptualized either as negotiation, where individuals join their separate ideas, or collaboration, where people engage together as an ensemble. Middle-class European-Americans commonly have a negotiation-model of collective knowledge-construction, but a collaboration model that fits within a holistic worldview is more common in Indigenous-heritage communities of the Americas. Notably, these culturally-based epistemological ideas about negotiated or collaborative sense-making are reflected in children's interactions with others during play, conversation, and other activities.

In line with these ideas, Bang and Medin's (2010a) take on an epistemological resources model represents both a developmental and sociocultural approach to understanding epistemological development. In their study of culturally specific "relational epistemologies", they have found that regardless of whether they live in rural or urban environments, European-American and Native American (specifically Menominee) children organize their knowledge about the natural world in different ways. For example, Menominee children are more likely to justify their knowledge of the natural world in terms of dynamic systems, and use relational epistemologies to draw conclusions about natural phenomena and their own role in nature. Related developmental work using an inductive inference task provides further evidence that Menominee children are epistemologically precocious with respect to engaging in ecological reasoning (Ross, Medin, Coley, & Atran, 2003). Furthermore, much like their parents, older Menominee children are known to use conversational practices to promote

discussions about “native ways of knowing” with younger children (Bang, Medin, & Atran, 2007).

They attribute these differences in viewpoints to the culturally variable epistemological practices experienced throughout development in family contexts. For example, they report that indigenous families—including those who live in urban environments—draw more attention to natural phenomena, causal systems, and epistemological phenomena during walks in nature (A. Marin & Bang, 2015; A. M. Marin, 2013). Compared to European-American families, Menominee families are more likely to display distinct modes of what consideration, responsibility, and contributions to nature mean (e.g. thanking plants for soothing children’s scrapes). Furthermore, Menominee parents also more frequently ask questions to guide attention, promote observations and assess knowledge about the natural world, asking children to seek evidence to support conclusions (e.g. asking children looking at evidence of erosion why they have concluded that a river used to flow there; asking children to make predictions about species interactions given the shared resources they compete for). Unsurprisingly, Native American children are more likely to view humans as animals (Waxman, Herrmann, Woodring, & Medin, 2014), learn of humans as part of, rather than separate from nature (Dehghani et al., 2013; Medin & Bang, 2014a), and hold a dynamic systems perspective of the biological world (Medin & Bang, 2014b; Unsworth, 2012).

Bang and colleagues are not alone in studying cultural and parental practices as they relate to children’s epistemological development. Further research on family epistemological practices comes from Luce, Callanan, and Smilovic (2013). In their study, parents read a science-themed book with their 4- to 8-year-old children. Guided by

Kuhn, et al.'s (2000) framework of epistemological stances, they coded parents' expressions of epistemology-related information (e.g., using evidence to reason about an opinion, appealing to statements of fact that do not need evidence, or pointing out that knowing for sure may not be possible) while discussing four science-related topics. They also coded children's comments about evidence for two different science-related topics. Luce and colleagues found that variations in parents' tendency to express evaluativist epistemology (e.g. emphasize testable evidence as a way to address scientific questions) was correlated with the children's own focus on evidence in discussions about scientific topics. Interestingly, they also found variation in parents' expressions of epistemological information by children's age and gender for particular topics. They conclude that to the extent that children experience different conversational environments, they may seek different types of answers to questions, become familiar with different ways of thinking about "knowing," and develop different strategies for being selective about learning from the testimony of others.

Examining the conversational dynamics that may be at play in children's developing understanding of probable and impossible events, Nolan-Reyes, Callanan and Haigh (2016) found that parents' speculation about potential mechanisms for improbable events predicted young children's possibility judgments for similar events, and accounted for more variance in children's judgments than age did. Furthermore, parents' skepticism regarding mechanisms for impossible events was negatively correlated with children's judgments about the possibility of improbable events. Additionally, children's overall causal justifications for their judgments were correlated with parents' talk about speculative mechanisms. Results underline the importance of conversation with parents

for young children's developing understanding of how claims about the improbable and impossible could be evaluated and justified or rejected.

Work on children's treatment of messages regarding improbable and impossible events also suggests that children's religious backgrounds may influence their epistemological understanding. Harris, Pasquini, Duke, Asscher, and Pons (2006) found that children's ontological claims about real, invisible, supernatural, or scientific entities extend beyond their first-hand encounters with instances of a given category. Children readily endorse the existence of entities that they cannot see for themselves such as germs, oxygen and God (but not fictional entities such as mermaids, ghosts or flying pigs). As Harris and Koenig (2006) point out, children's understanding of God's special powers, the biological life cycle, or the afterlife shows that their acceptance of others' testimony extends beyond the empirical domain.

Along these lines, Corriveau, Chen, and Harris (2015) asked 5- and 6-year-old children to make judgments about the reality status of protagonists in realistic, religious, and fantastical stories. Children from secular backgrounds were more likely than those from religious backgrounds to deny that the protagonist in religious stories was a real person. This supports the possibility that children's skepticism towards improbable and impossible scenarios is in part tied to their minimal exposure to speakers who discuss and endorse miraculous possibilities. Further supporting this is evidence that Iranian children, who are regularly exposed to religious narratives in daily life, were prone to think of both realistic and fantastical figures in stories as real (Davoodi, Corriveau, & Harris, 2016). Thus, children justify or reject beliefs about improbable scenarios on the basis of the religious epistemological values endorsed in their lives.

In the domain of testimonial learning, Suárez and Koenig (in press) found that parents' tendency to make evaluativist epistemological judgments (Kuhn et al., 2000) predicted their children's relative reluctance to attribute knowledge to, or endorse the conclusions made by, a speaker who made unsound inferences or guesses. Along these lines, Suárez and Koenig (in prep) also found that parents' evaluativist epistemological understanding was just as good of a predictor of children's appreciation for a well-calibrated speaker as their children's age. That is, children whose parents display a relatively sophisticated epistemological orientation are more likely to make social learning decisions informed by their own understanding of the nature and justification of knowledge.

It should also be noted that not only are individual's epistemological beliefs related to learning outcomes—so are their parents'. As reviewed previously, Suárez and Koenig (in press; in prep) found that children whose parents made evaluativist judgments were more likely to do so themselves. That is, regardless of age, preschool and young school-aged children are more likely to attribute knowledge to, endorse the conclusions of, and make positive judgments about speakers who reason appropriately about evidence, and use it to calibrate the certainty of their predictions. Similarly, children's talk about evidence during conversations about scientific controversies is reflective of parents' conversational expressions of epistemological perspectives. This suggests, but does not conclusively demonstrate, that parents' style of conversation may cultivate epistemological beliefs in their children that mirror their own, which in turn impacts children's learning outcomes. Future research should clarify whether this is the case, as it has important implications not only for the experiences that support children's ability to

optimize their own learning.

Despite the limited experimental research examining the role of social, contextual, and cultural influences on the development of epistemological beliefs, correlational and observational findings strongly point to culturally-specific family conversation and practices as a likely source of individual differences.

The Emergence of Mature Epistemological Beliefs. As Chandler, Hallett, & Sokol (2002) note, it seems counterintuitive that in so many studies examining the developmental progressions of epistemological beliefs, dualism (i.e. objectivism or absolutism) is the initial phase identified regardless of the age range being studied. Why do the stages in the pre-college population look so similar to those identified in late adolescence and adulthood? Furthermore, why is there so much individual variation in epistemological beliefs even among college students and older adults? Some of the possibilities listed by researchers include: early onset, late onset, recursion, suppression (Chandler et al., 2002), and domain dependence (Kuhn & Weinstock, 2002).

In other words, developmental models and research are challenged by evidence that "just about every conceivable sort of epistemic development has been shown to characterize persons of just about every conceivable age" (Chandler, Hallett, & Sokol, 2002, p. 161). This lack of coherence in developmental evidence and its interpretations have led Chandler and colleagues to argue that epistemological development is recursive: people pass through epistemic levels repeatedly within and across domains of epistemic cognition. It is not clear what evidence, beyond the evident lack of coherence among research findings, is being used to inform this hypothesis.

Critiquing this view, Elby, Macrander and Hammer (2016) argued that the

recursion proposal is similar to the inelegant proposal of planetary "epicycles" as an effort to rescue Ptolemaic theories of celestial motion. Their epistemic resources model provides a comparatively parsimonious account of epistemological development, arguing that development is nothing more or less than the contextually-situated construction and coordination of resources which are employed when their use is productive. In this view, researchers' varied attempts to define, measure, and interpret evidence of epistemological understanding suffers from a lack of coherence across methodologies, contexts in which development is studied, and domains of information participants reason about.

Indeed, as Greene et al. (2016) point out in their review of frameworks in epistemic cognition, researchers have yet to appropriately and systematically document how context and domain influence participant responses. As a result, apparent developmental trends may or may not be an artifact of researchers' own assumptions and methodologies. They also point out that notions of epistemic development from Perry (1970) and beyond have been rooted in a distinction that sees development as a slow, broad, maturational process. In reality, changes in epistemological views may be rapid and flexible adaptations to changing environmental influences. However, to this I would add that we ought to be wary of describing epistemological change as *independent* of maturation, because we cannot discount the possibility that context-dependent changes in epistemological viewpoints may be more or less successful depending on general patterns of development.

Chapter 3: Individual Differences in Adolescence and Adulthood

In the wake of the publication of Schommer (1990), Kuhn and colleagues (2000), and others' instruments measuring epistemological beliefs, there was an explosion of studies reporting correlates of specific epistemological beliefs in adolescents and adults. These findings hint at possible processes and influences that may contribute to individual differences in epistemological understanding, and also point to possible consequences of these variations. Together, this work suggests that differences in adolescents' and adults' epistemological understanding may be a result of, and uniquely contribute to, individual variations in cognitive, academic, social, and cultural factors.

Culture, context and gender. In Chapter 2 I discussed how social and cultural contexts predict individual differences in epistemological development in childhood. Here in Chapter 3, I discuss individual differences in adolescents' and adults' epistemological understanding, as well as their predictive relation with various academic, social, developmental, and cognitive outcomes.

Epistemological beliefs in adolescents and adults vary as a function of shared sociocultural values, such as collectivist vs individualistic values, gendered values, and values concerning power and conformity. For example, students from Korea— a country with relatively collectivist values— are more inclined to tie an inter-dependent self-construal with learning outcomes than students from the more individualistic US (Youn, 2000). Along these lines, college students in Oman were more likely than US students to accept scientific authorities as a basis of scientific truth, and also more likely to regard scientific knowledge as simple and certain; the latter was particularly true of Omani men as compared to Omani women (Karabenick & Moosa, 2005). Another study pointing to

systematic gender differences in epistemological beliefs reveals that female high school students reported having more constructivist beliefs about conceptual physics knowledge than male students, whereas male students tended to have more constructivist beliefs about procedural physics knowledge than female students (Muis & Gierus, 2014). Additionally, in a study exploring the way values about conformity and power, as well epistemological understanding, are related to gender orientation in German university students, Kessels (2013) found that the more male students valued power, the less they advocated evaluativist reasoning. Similarly, the more female students valued conformity and identified with feminine traits, the less they advocated for evaluativist reasoning.

In a fascinating study on changing epistemologies under conditions of social change, Weinstock (2015) examined the epistemological understanding of three generations of Muslim Arab women from two communities in Israel: a small, homogenous village and a large, diverse city. Village adolescents were more subjectivist than their mothers and grandmothers, which was tied to their greater exposure to diverse people and ideas; however, there was not such a sharp generational divide in the urban sample, where the mothers and grandmothers were also exposed to such diversity. Thus, the changing social, economic, and political climate within which an individual is situated can have a marked impact on their epistemological beliefs, above and beyond effects of a shared ethnicity or heritage.

In sum, there are a number of interesting ways in which individual differences in adolescent and adult epistemological beliefs interact with cultural and contextual factors such as ethnicity, generation, lifestyle (e.g. urban vs. rural), conformist and authoritarian values, and gender. However, it is unclear to what extent these are present in childhood,

or what developmental and causal mechanisms are involved in the enculturation of epistemological understanding.

Epistemological reasoning in everyday life. Individual differences in epistemological understanding are also predictive of adolescents' and adults' learning and reasoning in everyday life. For example, individual differences in epistemological understanding have also been found to predict moral reasoning across a number of cultures, with relatively absolutist beliefs being associated with a tendency to treat moral beliefs as objective facts (Bendixen et al., 1998a). Indeed, epistemological understanding accounts for unique variance in moral reasoning above and beyond age, education, gender, and even syllogistic reasoning skills (Bendixen, Schraw, & Dunkle, 1998b).

In the domain of identity development, relativistic epistemological thinking has been associated with a mature identity status in healthy adolescents. In contrast, there was no such correlation in a sample of adolescents who were hospitalized for unspecified psychiatric problems (M. Chandler, Boyes, & Ball, 1990). Along these lines, Boyes and Chander (1992) found that adolescents' epistemological understanding—specifically their tendency to acknowledge subjectivity and uncertainty—was predictive of the extent to which they had actively reflected upon, explored, and invested in their personal identity development.

Variations in epistemological understanding have also been found to predict the competence with which individuals learn or reason in high-stakes professional contexts. For example, medical students with more advanced epistemological beliefs used more comprehensive, diverse and effective strategies during interviews and exams with patients (Oh, Chung, Han, Woo, & Kevin, 2016). Examining the relation between

epistemological beliefs and teaching behaviors. Roth and Weinstock (2013) reported that teachers who were rated by students as providing high levels of autonomy support—operationalized by the authors as the extent to which they provided students with rationales for prosocial behavior, and the extent to which teachers took student perspectives— also scored as having more advanced personal epistemologies. Furthermore, individuals' epistemological understanding is predictive of jurors' ability to represent and argue about evidence, as well as the certainty of their verdict choices—even after controlling for juror age, educational level, and gender (Weinstock, 2009; Weinstock & Cronin, 2003).

Academic and Educational Outcomes. There is a particularly large amount of evidence describing how individual differences in students' epistemological beliefs predict various academic outcomes in a wide range of disciplines. Among the first to report such findings were Schommer and colleagues (1992), who found that that a belief in knowledge as simple (rather than complex) was negatively correlated with mathematical comprehension and meta-comprehension. Furthermore, they found that the more students believed in simple knowledge, the more overconfident they were in their own comprehension. Notably, results from path analysis showed that the predictive relation between simple knowledge and mathematical comprehension was mediated by an overall processing strategy. That is, the more students believed that knowledge is simple, the more they engaged in memorization strategies, and the less they were able to effectively summarize important concepts.

Accordingly, Schommer and colleagues (1992) argued that epistemic beliefs affect achievement both directly and indirectly. Problematically, there was no attempt to

establish this causal relationship experimentally, leaving open the possibility that the reverse was true: that is, that students with more sophisticated learning strategies develop more sophisticated concepts about the nature of knowledge. Furthermore, there was no attempt to account for possible third variables that could partially or completely account for these findings, such as IQ, need for cognition, executive functioning, SES, and so on.

Studies making causal claims about the effects of epistemological beliefs on learning based on correlational data are hardly unusual. Qian & Alvermann (1995) studied the epistemological beliefs of high schoolers and found that students' beliefs about the certainty and simplicity of knowledge, as well as the speed and ease of learning, were associated with greater resistance to conceptual change. The authors even used these findings to call for interventions on both students' and teachers' epistemological beliefs to improve their learning and teaching, respectively. Even though no causal relationships were established, findings were presented as such, and researchers did not consider that the reverse might be true; that is, students who had more success engaging in conceptual change may have grown to believe that knowledge is complex and uncertain, and learning is slow and effortful.

Examining the relation between epistemological beliefs and reading comprehension, Kardash & Howell (2000) presented undergraduate students with texts containing information about the link between HIV and AIDS that were both consistent and inconsistent with their own understanding of this health issue. They found that epistemological beliefs about the speed of learning were related to the overall number of strategies students engaged in to make sense of the texts. Strategies for accepting or resolving apparent ambiguities in text were related positively to delayed recall, and

cognitive processes for developing awareness were related negatively to the number of distorted conceptions developed by students. Again, these correlational findings were presented using causal language despite the lack of experimental manipulations of epistemological beliefs, and author inattention to third variables (e.g. executive functioning).

Strømsø, Bråten and Britt (2010) also report a link between epistemological beliefs and reading comprehension. Controlling for readers' prior knowledge and the text's comprehensibility, they found that readers who believe strongly in relying on personal interpretations rather than on authorities trusted text less, and used the document's content or their own opinion as criteria for judging trustworthiness. They also found that readers who believed that knowledge claims should be critically evaluated rated the science text as more trustworthy.

Findings of a link between personal epistemology and learning outcomes extend to virtual learning contexts. Strømsø and Bråten (2010) found that dimensions of Internet-specific epistemic beliefs explained unique variance in Internet-based search, help-seeking, and self-regulatory strategies. Here, self-regulatory skills were conceptualized as the operational aspect of metacognition, including the planning, monitoring, and evaluation going on during learning and problem-solving. The authors found that students who emphasized that course-related knowledge located on the Internet consisted of specific facts and details were less likely to report that Internet-search results were a problematic source of information; they were also more likely to report help-seeking strategies rather than self-regulatory strategies during Internet-based learning. In contrast, students who indicated that Internet search results were a set of

claims that need to be checked against reason and prior knowledge were more likely to report employing self-regulatory strategies when using the Internet during coursework. Interestingly, this points strongly to the possible role of cognitive self-regulation strategies in epistemic cognition; however, it is not clear to what extent this conception of self-regulation maps on to what developmental psychologists refer to as executive functioning.

Muis and Franco (2009) examined relations between epistemic beliefs, achievement goals, learning strategies, and achievement among undergraduates studying educational psychology. Testing the hypothesis that epistemic beliefs influence processes of self-regulated learning, they asked students to recollect what metacognitive learning strategies they had employed as they completed course tasks. Using structural equation modeling techniques, researchers found that the epistemological beliefs activated during learning predicted the types of achievement goals students adopted, which subsequently predicted the types of learning strategies they used in their education course, and their achievement therein. Moreover, achievement goals mediated relations between epistemological beliefs and learning strategies, and learning strategies mediated relations between achievement goals and achievement. These findings suggest that any effects that epistemological beliefs may have on learning are not straightforward, but rather interact with a number of other cognitive and social factors to promote learning.

It should be noted that despite all of this work suggesting that more sophisticated epistemological beliefs are predictive of better learning outcomes in mathematics, physics, reading comprehension, and so on, there is also evidence that sophisticated epistemological beliefs may not be necessary for deeper processing and enhanced

learning. Franco, Muis, Kendeou, Renellucci, Sampasivam and Wang (2012) found that when individuals' epistemological beliefs were consistent with the knowledge representations in their assigned texts, they performed better on various measures of learning (use of deeper processing strategies, text recall, and changes in misconceptions) than when their epistemological beliefs were inconsistent with the knowledge representations. In other words, findings suggest that an individual will focus more on aspects of the content that are consonant with his or her epistemological beliefs such that, depending on how content-to-be-learned is presented, more mature epistemological understanding may not always result in enhanced learning.

Results from a meta-analytic review conducted by Greene, Cartiff and Duke (2018) indicate that the correlation between epistemological understanding, as measured predominantly in terms of beliefs, and academic achievement is small, but meaningful. Additionally, they found that epistemological understanding predicted academic achievement as early as elementary school, and this continued throughout graduate school. Thus, epistemological understanding seems to be an important and consistent predictor of academic success throughout development.

In sum, it appears that throughout development, individual differences in ones beliefs and reasoning about the nature and justification of knowledge are associated with a wide range of cultural and contextual factors such as generation, religious background, or gender. Furthermore, epistemological understanding has been consistently found to predict a wide range of developmental, academic and social outcomes. Interestingly, a number of studies indicate that this predictive relation holds even after accounting for variability in age, gender, education, and even certain cognitive skills.

Chapter 4: Mechanisms and Effects of Epistemological Development

To what extent do sophisticated personal epistemologies enhance critical thinking and learning (and vice versa)? In this chapter, I address important theoretical and methodological questions concerning the mechanisms of epistemological development and the widespread (mis)use of correlational evidence. In a review of the role of self-regulation of academic learning and performance, Zimmerman (2008) characterized the question driving this body of research as a quest for understanding "how students become masters of their own learning processes" (p. 167). As Maggioni and Parkinson (2008) argue, a key aspect of this progress is the development of critical abilities that help learners to search for meaning, allowing them to be responsible actors in the learning process. It is difficult to imagine that epistemological evaluations— such as considering the quality of available information, reflecting on whether knowledge can be obtainable in a certain situation, and choosing how to assess reality— could have no influence on learning. Similarly, it makes intuitive sense that the practice of knowledge-acquisition would itself require students to develop their critical thinking and epistemological reasoning skills. However, as I review here, the causal evidence available is limited, often ambiguous, and does not speak to developmental processes as they occur in everyday informal learning contexts.

What do we know about the causal influences on the development of epistemological beliefs? As reviewed in earlier chapters, existing models of personal epistemology are inconsistent in the extent to which they address mechanisms of change and development. However, we do know that there are a number of individual and contextual differences in epistemological understanding— varying by generation, urban

vs. rural lifestyles, ethnicity, religion, gender, and more— which strongly point to culturally- and contextually-dependent mechanisms of change. However the individual differences literature does not offer a particularly specific or mechanistic account of epistemological development. In this chapter, I review work from the developmental and educational psychology literatures that speaks more directly to mechanisms of epistemological development. Furthermore, I identify a major gap in these literatures, which I aim to address with the current study.

How Epistemological Beliefs Change. Work on the developmental changes (e.g. Kuhn et al., 2000) in epistemological beliefs does indicate that a combination of cognitive maturation and acquisition of expertise contribute to the increasing sophistication of these perspectives throughout life. For example, Kuhn's findings on experts suggest that acquiring a richer base of content knowledge in various domains supports more sophisticated and stable epistemological views within domains of expertise— for example, rabbis, philosophers and mathematicians hold evaluativist personal epistemologies in the domains of theology, philosophy and mathematics, respectively.

Researchers motivated by the idea that promoting epistemological development will improve academic outcomes and science learning, over the last decades, have been working productively to understand how more adaptive epistemic cognition can be promoted (Greene et al., 2016a). From the educational psychology literature comes clear evidence that engaging in critical thinking and other academic interventions improve epistemological sophistication. For example, in elementary classrooms, domain-specific interventions in science (e.g., Metz, 2011; Ryu & Sandoval, 2012), mathematics (e.g.,

Mason & Scrivani, 2004; Verschaffel et al., 1999), history (Nokes, 2014; VanSledright, 2002), and language arts (Reznitskaya et al., 2012) suggest how engagement in scaffolded disciplinary practices can change students' beliefs and thinking about knowledge and knowing within these disciplines. Such practices include the appropriation of norms surrounding the use of evidence and causal claims within a discipline (e.g. how to evaluate historical claims like a historian; how to teach biology like a biologist), encouragement from teachers to engage in evidence-based argumentation and inquiry dialogue, and supporting children's abilities to design experiments and interventions. It is not currently known if changes brought about by such interventions affect individuals' beliefs and thinking about knowledge and knowing outside formal educational contexts or across different academic domains; furthermore, it is not clear to what extent these interventions support epistemological development independent of the effects of knowledge-acquisition. That is, does "learning to learn" like a historian support epistemological development to a greater extent than simply learning historical *content*?

Attempting to achieve a domain-general change in epistemic understanding, Muis and Duffy (2013) developed an instruction intervention to change the epistemic climate at the classroom level. Based on constructivist teaching practices, the intervention involved teacher modeling of critical thinking about content (for all domains), evaluation of multiple approaches to solving problems, and habitually making connections to prior knowledge. Students' epistemological beliefs shifted midway through the semester; in contrast, students in a control classroom who did not receive this intervention maintained a consistent level of epistemological beliefs throughout the semester. Beyond a change in

epistemological beliefs, intervention students' use of critical thinking, elaboration strategies, and epistemological reasoning also significantly increased, as did their levels of self-efficacy for learning statistics and their overall grades. There were no such changes for control group.

More experimental work has brought to the forefront the potential role of critical thinking about conflict in the development of epistemological beliefs. Indeed, inducing cognitive conflict, either via direct instruction or refutation texts, appears to promote the development of sophisticated epistemological beliefs (e.g. Ferguson, L. E., Bråten, I., & Strømsø, H. I., 2012). For example, Kienhues, et al. (2008) used an experimental design featuring random assignment, making it possible to make clear inferences about the role of direct instruction as a cause of conceptual change. However, questions were rightly raised by study authors about the stability and sophistication of domain-specific epistemological beliefs, particularly when the learner's domain knowledge is shallow. Gill, Ashton, and Algina (2004) took a slightly different approach to experimentally inducing conceptual change, termed "augmented activation", which involved giving a treatment group an instructional intervention promoting cognitive conflict and critical thinking. They demonstrated greater overall change in implicit epistemological beliefs than a control group, and found partial support for the role of systematic processing (e.g. engaging in "deep" rather than "surface" thinking) as a mediator of the relation between general epistemological beliefs and change in specific epistemological beliefs.

It should be noted that this work provides us a limited understanding of the duration, scope, and generalizability of changes in epistemic beliefs as a result of such interventions. Whether these changes represent short-term or domain-specific ways of

thinking about the nature of knowledge and knowing remains to be seen, and we would be remiss to promote the funding and implementation of any student, teacher or family-level interventions without first considering these possible limitations.

Furthermore, it should be noted that there is no published causal evidence specifically concerned with how epistemological beliefs change in everyday developmental contexts outside of the classroom (although there is work framed in terms of theory of mind development (for a review see Ronfard et al., 2017)). Observational work on parents' epistemological practices, particularly within the context of conversation about the natural world (e.g. Bang & Medin, 2010; Luce, Callanan & Smilovic, 2013), point to possible mechanisms by which children's epistemological development is constructed by social processes. But experimental work is needed to better understand whether conversational expressions of epistemological perspectives influence children's epistemological beliefs, or if relations between parents' and children's epistemological understanding could be partially or entirely explained by other factors (e.g. SES, intelligence, executive functioning). Despite the evidence that epistemological development that begins before the school years, as well as reported links between parents' and children's epistemological beliefs, important questions about mechanisms of epistemological development in everyday contexts remain unanswered. Along these lines, the field would also benefit greatly from thorough investigations of the roles of ethnicity, language, socioeconomic status, and individual differences in cognitive skills in children's everyday epistemological thinking and development.

Questioning Assumptions about Effects of Epistemological Beliefs on Learning. As I have reviewed, there is a large and ever-growing body of literature dedicated to

documenting the predictive relation between epistemological beliefs and individuals' learning outcomes, including but not limited to mathematical, scientific learning, conceptual, and testimonial learning. Although it intuitively makes sense that one's beliefs about the nature and justification of knowledge would have consequences for the way knowledge is constructed and evaluated in everyday life, there has been a surprising dearth of experimental evidence from outside academic contexts supporting this notion. Also troubling is the lack of research on other factors that may partially or completely account for reported relations between epistemological beliefs and certain outcomes (e.g. general intelligence, socioeconomic factors, executive functioning).

Part II: Methods

Thus far, I have overviewed the predominant theoretical frameworks on personal epistemological understanding, described empirical findings on its development and individual differences, and assessed research on associated learning outcomes. In Part II of this manuscript I detail the research questions, aims, hypotheses, predictions and methodology. Specifically, in Chapter 5, synthesize the reviewed literatures to justify the research questions for the present study, and outline specific aims. In Chapter 6 I describe research design and methods, and in Chapter 7 I discuss specific hypotheses and predictions in terms of my study design.

Chapter 5: Research Aims

Here I synthesize the reviewed literatures that motivate the research questions for the present study, and outline specific hypotheses and predictions. I begin by outlining three major gaps in the literature on the development of epistemological beliefs, focusing on three central topics: 1) mechanisms of epistemological development in everyday contexts; 2) assessing epistemological understanding explicitly versus indirectly as done with social learning tasks; and 3) cognitive and contextual sources of individual differences in epistemological understanding.

Stance	Assertions	Critical thinking
Absolutist	Assertions are **facts** that are correct or incorrect in their representation of reality.	Comparing assertions to reality to **determine truth value**.
Multiplist	Assertions are **opinions** freely chosen by and accountable only to their owners.	**Irrelevant**.
Evaluativist	Assertions are **judgments** that can be evaluated using to criteria of argument and evidence.	**Valuable** way to promote sound assertions.

Table 5.1. Epistemological beliefs as proposed by Kuhn, Cheney and Weinstock

I will be using Kuhn's (2000) framework on epistemological beliefs to guide this work, as did Luce, et al. (2013) in their observational study of parent-child dyads' discussions about science. According to this framework, epistemological beliefs can be characterized as absolutist, multiplist, or evaluativist, which refer to the extent to which an individual acknowledges the subjective and/or objective dimensions of knowledge. Absolutist beliefs hold that there is an objective standard of truth, and claims are either right or wrong. Multiplist beliefs hold that claims are subjective opinions which can be neither absolutely, nor relatively, right or wrong. Finally, evaluativist beliefs, which are more sophisticated due to their integration of the subjective and objective dimensions of knowledge, hold that claims can be relatively right or wrong, and weighed against

evidence. For this reason, evaluativist beliefs are typically thought to be most like scientific thinking.

Research Aims. Efforts to clarify the nature and development of epistemological understanding would be extremely informative about basic socio-cognitive and developmental processes, and help to mend fractures between different research traditions. Equally important are the implications of such research for educational and parenting practices meant to support children's learning and critical thinking.

Aim 1: To Study Mechanisms of Change and Development in Epistemological Beliefs. Existing models of personal epistemology are inconsistent in the extent to which they address mechanisms of change and development. The educational psychology literature provides evidence that engaging in critical thinking and other academic interventions promotes epistemological sophistication (e.g. Kienhues et al., 2008). However, these studies do not address how epistemological development occurs in young children or in informal learning contexts. Observational work from developmental psychologists on parents' epistemological practices, particularly within the context of conversation about science and the natural world (e.g. Bang & Medin, 2010b; Luce et al., 2013), point to possible mechanisms by which children's epistemological beliefs are co-constructed. However, there is no experimental work testing whether such interactions have effects on children's epistemological beliefs, or if parent-child similarities in epistemological beliefs can instead be explained by other factors (correlation vs. causation problem). *Thus, the central aim of this dissertation is to test for effects of conversational expressions of epistemological perspectives on young children's epistemological beliefs.*

Aim 2: To Question Assumptions about Effects of Epistemological Beliefs.

There is a burgeoning body of literature dedicated to documenting the predictive relation between epistemological beliefs and individuals' learning outcomes, including, but not limited to, mathematical, scientific, conceptual, and testimonial learning (Sandoval, Greene & Braten, 2016). Furthermore, parents' epistemological beliefs, as measured in a questionnaire (Kuhn, et al., 2000; Barzilai & Weinstock, 2015), predict children's critical social learning from speakers who vary in their reasoning about evidence (Suárez & Koenig, in press; in prep). Although it intuitively makes sense that individuals' (or parents') beliefs about the nature and justification of knowledge would have consequences for the way children's knowledge is constructed (or co-constructed) and evaluated, there has been a surprising dearth of experimental evidence supporting this notion. Most alarmingly, correlational evidence is widely used in the literature to support the conclusion that epistemological development will cause improved educational and developmental outcomes (e.g. Qian & Alvermann, 1995). This has led to a wave of teacher and student interventions meant to change epistemological practices within a specific academic discipline (e.g., Metz, 2011; Ryu & Sandoval, 2012), which are only occasionally based on experimental evidence. Even rarer is work examining the scope and duration of such interventions. *Thus, here I test for effects of epistemological beliefs on young children's evaluations of, and learning from, informants who vary in reasoning competence; as well as their epistemological beliefs in situations that vary in the perceived objectivity or subjectivity of the question at hand.*

Aim 3: To Examine Possible Effects of Individuals' Cognitive Skills. A number of studies suggest that individuals' self-regulation strategies—conceptualized in the

learning sciences literature as the planning, monitoring, and evaluation that occurs during learning and problem-solving (Brown 1987; Bråten, 1991)—may moderate the effects of epistemological beliefs on critical thinking and learning (e.g. Strømsø and Bråten, 2010.) However, the role of executive functioning (EF) in these processes has yet to be examined. EF is a set of cognitive self-regulatory processes including working memory, inhibition, and cognitive flexibility (Zelazo, et al., 2003). Like epistemological beliefs, EF has been implicated in a wide range of developmental and academic outcomes including social cognition (Carlson, et.al, 2004), mathematics achievement (Bull, et al., 2008), and selective testimonial learning (Doebel, et al, 2016). Similarly, children's verbal intelligence (verbal IQ) has been implicated in a wide range of developmental and academic outcomes (Sternberg, Grigorenko & Bundy, 2001; Deary, Strand, Smith & Fernandes, 2007; Deary, Weiss & Batty, 2011; Batty, Wennerstad, Smith, Gunnell, Deary, Tynelius, Rasmussen, 2009). *Thus, here I examine if individual differences in children's EF and IQ moderate or mediate the effects of epistemological framing on children's epistemological beliefs, calibration, and evaluations of others' calibration.*

Aim 4: To Identify Links Between Individual Differences in Children's Epistemological Understanding and Parent Characteristics. As reviewed earlier, parent characteristics predict individual differences in children's social learning. Specifically, parents' epistemological beliefs predict 4- to 6-year-olds' decisions about whether to trust informants who make unsound inferences or guesses (Suárez & Koenig, in press), and parent epistemological beliefs, authoritarianism (or the tendency to value deference to authority), and need for cognition (or the inclination towards engaging in effortful cognitive activity) predict children's evaluations of speakers who succeed or fail to use

evidence to calibrate the certainty of their predictions (Suárez & Koenig, in prep). Although links between parents' conversational expressions of epistemological stances do predict individual differences in children's evidence talk (Luce, et al., 2013), there is no published work examining how parents' epistemological responses on questionnaires correspond to children's conversational epistemological expressions. Similarly, there has been no examination of children's conversational expressions as they relate to parent authoritarianism, social conformity and need for cognition. *Thus, here I examine if individual differences in parents' EU, authoritarianism, and need for cognition are related to their children's own EU, use of statistical evidence in learning, and/or learning from agents who vary in their own learning from statistical evidence.*

Chapter 6: Participants, Design and Procedure

Participants. Participants were 54 6- and 7-year-old children and their parents. This age group was selected because it appears to be the age at which various forms epistemological understanding are emerging, such as the recognition of the value of reasoning and thinking as a way to construct knowledge and solve problems (Pillow, 2012; Amsterlaw, 2006). Furthermore, this is the age at which there is suitable variability in children's selective learning and epistemological judgments as found in Suárez and Koenig (2018). A sample size of at least 40 was chosen after an a priori power analysis with the program G* power (Erdfelder, et al., 1996) indicated this would provide sufficient statistical power to find within-subject intervention effects of at least moderate size. Participants were recruited from the Institute Participant Pool (IPP), a database of families from the greater Twin Cities areas who have indicated interest in participating in research. Participants were screened to ensure that they spoke English fluently and had no visual, hearing or cognitive impairments that would interfere with their ability to participate in the study.

Design. This study features a within-subjects experimental design, as well as a between-subjects correlational design to identify potential cognitive and parental factors predictive of individual differences in children's epistemological understanding.

Materials. Children's executive functioning was assessed using the Minnesota Executive Functioning Scale (MEFS), an iPad-based, developmentally-appropriate and adaptive assessment. Their verbal knowledge (Verbal IQ) was assessed with the verbal component of the Kauffman Brief Intelligence Test II (KBIT 2). Children read a series of short vignettes displayed on a laptop with the experimenter in which characters disagreed

about an issue (see Appendix). Children were also presented with videos of speakers reasoning about causal properties of objects on a laptop. Parents were asked to complete five paper questionnaires: a basic demographic questionnaire, a questionnaire on epistemological perspectives (Barzilai & Weinstock, 2015), a questionnaire assessing authoritarian values (Feldman & Stenner, 1997), a questionnaire assessing social conformity (Feldman, 2003), and a questionnaire assessing Need for Cognition (Caccioppo & Petty, 2001).

Procedure. The approximately 1-hour-long study occurred in 4 phases: (1) Cognitive assessments, (2) Baseline Assessments (Pretest), (3) Epistemological Framing (Intervention), and (4) Posttest Assessments. Within the Pretest and Posttest phases, there were two sub-phases, Calibration and Vignettes, the order of which was counterbalanced. Sessions were videotaped with parental consent and coded for reliability by two research assistants, one of whom was blind to phase. To assess how blind the coder truly was, they were asked to guess which phase they were coding if they had a hunch. Binomial analyses revealed that coders did not guess which phase they were coding at rates significantly different from chance, $ps > 0.05$. Thus, coders were indeed blind to phase.

Phase 1: Cognitive Assessment. Children's executive functioning was assessed using the Minnesota Executive Functioning Scale (MEFS), a 5-minute long assessment administered via iPad that is developmentally appropriate for 6 and 7-year-olds (Carlson & Schaefer, 2012). Furthermore, their verbal knowledge was assessed with the Verbal Scale of the Kaufman Brief Intelligence Test, 2nd edition (KBIT 2; Dumont & Willis, 2008). This assessment involves individually administered verbal and nonverbal tasks that do not require reading or spelling, making it ideal for a quick assessment of young

children's verbal skills.

Phase 2: Baseline Assessments (Pretest)*. Epistemological Assessments.* With an experimenter, children read 3 vignettes in which two characters disagreed about an issue with no clear answer or resolution. The issues represented one resolvable question of fact ("Objective"; e.g. whether it is raining outside), one issue of interpretation ("Mixed"; e.g. whether an exotic animal makes for a good pet), and one potentially unresolvable matter of taste ("Subjective"; e.g. whether a painting is pretty) as indicated by adult ratings. For each vignette, children were asked a series of questions concerning the cause of the disagreement, how it might be resolved, and whether there could be truth to both claims (see Appendix). Importantly, in this phase the experimenter responded positively to encourage further discussion, explanation and elaboration (e.g. "Ah, interesting"; "Thanks for sharing!"; "How come?"; "I see; could you tell me more?"), but did not make any statements indicating or promoting a specific epistemological stance. Children's individual responses were collected, and their body of responses for each vignette— including their spontaneous remarks, explanations, elaborations, justifications, and interpretations— were coded as absolutist (A), evaluativist (E) or multiplist (M) based on whether they recognized that knowing involved objective fact, subjective interpretation, or both. To be clear, children's stance was not decided based on whether they recognized the existence of objective facts and/or subjective opinions. Instead, these determinations were made based on whether or not children believed that objective facts and/or subjective opinions <u>had any bearing on determining what is true, correct, or right.</u>

Calibration and Speaker Evaluations. The procedure and measures for this phase have been taken from Suárez and Koenig, in prep; see Table X. Children watched a series

of 3 brief videos (order counterbalanced) in which a demonstrator placed a set of 4 identical blocks (or toys) onto a toy box (or magnetic board) for two naïve speakers. Each trial featured a set with a unique appearance, and a unique proportion of causally effective blocks that appeared to make the box light up or to be magnetic: 50%, 75%, and 100% causally effective items (order counterbalanced). On each trial, two speakers in the video were prompted by the demonstrator to predict whether an untested 5th block from the set would be effective. Children were asked to make their own predictions about the 5th block and rate their certainty as "Very Sure", "Kinda Sure", or "Not So Sure" using a cartoon scale (Appendix). Then, they watched as one speaker (the Calibrator) made predictions in accordance with the evidence (e.g. after seeing 50% effective blocks, saying she was "not so sure" if the 5th item would work; after seeing 75% effective blocks, saying she was "kinda Sure"; after seeing 100% effective blocks, saying she was "very sure";). The second speaker (Overconfident) was always "very sure" the new block would work, even in the face of ambiguous evidence (e.g. blocks that were 50% or 75% effective). Children's evaluations of reasoners' competence was assessed in each trial by asking "Who has the best way of thinking—Speaker A, Speaker B, or both?". After the 3 trials, children were asked two additional questions to assess their epistemic attributions and personal preferences ("Who knows more: Speaker A or Speaker B?", and "Who do you like more: Speaker A or Speaker B?").

Phase 3: Epistemological Framing (Intervention). As in the Vignette portion of the pretest, children and the experimenter read 3 vignettes together concerning one resolvable question of fact ("Objective"; e.g. when grandma married grandpa), one issue of interpretation ("Mixed"; e.g. whether coach is nice or mean), and one potentially

unresolvable matter of taste ("Subjective"; e.g. whether a board game is boring). However, in order to promote more sophisticated epistemological reasoning and beliefs, *children were exposed to the experimenters' epistemological framing, using questions and statements that reflected an evaluativist epistemological perspective.* To do this, there were two major differences between the pretest and intervention phases. First, the experimenter asked all children some additional questions meant to encourage deeper reasoning about the certainty, construction, justification, and interpretation involved in "knowing" (see Appendix). Second, the experimenter would respond to the child's specific answers with feedback and additional questions meant to counter absolutist or multiplist ideas in favor of evaluativist perspectives. For example, if a child expressed the belief that a juju could either be a good or bad pet based on whether it is "wild", the experimenter would counter this absolutist idea by asking the child to consider if what makes for a "good" pet depends not only on objective facts about jujus, but also on personal preference or interpretation. Similarly, if a child indicated that the beauty of a painting is entirely a matter of opinion, the experimenter would suggest that while "pretty" or "ugly" paintings are in the eye of the beholder, there are certain objective standards by which art is evaluated (e.g. art experts will describe famous painters in terms of their innovation, technique, or content).

Throughout this conversation, children were also provided more support and suggestions when asked about ways in which the characters might try to "figure out" the matter at hand. Ideas that were in line with evaluativist beliefs and reasoning were particularly reinforced (e.g. "Great idea!", "Wow, that's a really clever way to think about it!"). In contrast, expressions of multiplist or absolutist epistemological beliefs were met

with enthusiastic interest (e.g. “Interesting, thanks for sharing!”, “Wow, you’re really making me think!”), immediately followed by an alternative perspective in line with evaluativist perspectives was also reiterated (e.g. “I have an idea! What if ….”).

Phase 4: Posttest. In this phase, the effects of this “epistemological framing” on children’s everyday epistemological judgments and social learning were assessed. Just as in the pretest phase, children were presented with 3 vignettes in which two characters disagree, with no clear resolution, about issues ranging from immediately resolvable questions of fact (e.g. when pianos were invented), issues of interpretation (e.g. whether a basketball team is good), and potentially unresolvable matters of taste or value (e.g. whether a movie was good). After reading each vignette, children were asked the same set of questions as in the pretest, and the experimenter did not provide any kind of feedback. Furthermore, children watched another set of 3 videos in which 2 reasoners—a Calibrator and Overconfident speaker— observed probabilistic evidence and made predictions, just as they did in the pretest.

Coding. Percent agreement between coders was at 97% overall, and 92% with regards to coding stance. Coder disagreements were resolved by reviewing to the videos together and jointly deciding how to code. Utterances that located the source of the disagreement exclusively in the world, made no allowance for legitimate diversity of opinion, and/or assumed that the world supplies the same answer to everyone were classified as *absolutist*. At the other extreme, responses that located the source of the disagreement exclusively within individuals, failed to recognize the need for evidence or evaluation of statements, and/or held that personal reaction is a legitimate basis for judgment which renders all opinions as equally valid, were classified as *multiplist*.

Responses were coded as *evaluativist* if they reflect coordinated objective and subjective considerations by requiring empirical or logical support for divergent positions, and/or envisioned agreed-upon criteria as alternatives to sheer multiplism.

Coders also noted the child's level of engagement during the intervention phase, meant to be an index of the effectiveness of the intervention on the individual. This three-level measure of engagement represented whether children were resistant, receptive, or elaborative for each vignette. If children ignored and/or rejected the experimenter's suggestions or evaluativist perspectives in a given vignette, they received a 0 out of 2 on the engagement scale (resistant). If children acknowledged and accepted—but did not elaborate upon—the experimenter's comments and suggestions, they received a 1 of out 2 (receptive). Finally, if children responded contingently to the experimenter with their own epistemological questions, ideas, and expressions of evaluativist perspectives, they received a 2 out of 2 on the engagement scale (elaborative).

Chapter 7: Hypotheses and Predictions

Hypothesis 1: Effects of Epistemological Framing. Adults' epistemological framing in the context of conversation about disagreements or controversies influences, and is reflected in, children's epistemological judgments and critical thinking in social learning. Consequently, I predict that there will be significant main effects of evaluativist epistemological framing on children's epistemological expressions during conversations about everyday controversies. That is, in the posttest children will make more comments reflecting evaluativist epistemological values, and less multiplist or absolutist comments, than children in the pretest. I also predict that after the intervention children will be more likely to indicate that a speaker who calibrates their certainty with evidence has the "best way of thinking", rather than a speaker who is always "very sure" no matter how ambiguous the evidence. Similarly, I predict that children will attribute more knowledge to the Calibrator in the posttest.

Hypothesis 2: Effects of EF and IQ. I hypothesize that executive functioning skills and verbal knowledge support the coordination of subjective and objective dimensions of knowing that characterizes evaluativist epistemological thinking, as well as on learning and critical thinking outcomes more generally. Thus, I predict that there will be main effects of EF and IQ, such that children with better EF and verbal IQ will be more likely to make evaluativist statements at baseline, and will show more critical evaluations and testimonial learning at baseline as well. Specifically, I predict that children with stronger EF skills will be *more* receptive to Evaluativist Framing.

Hypothesis 3: Predictive Relations Between Parent and Child Measures. I hypothesize that individual differences in parent characteristics are related to those in

their children. Specifically, I predict that children whose parents are relatively high in evaluativist beliefs and need for cognition, and relatively low in authoritarianism and social conformity, will make more evaluativist statements in the baseline phase— even after controlling for EF and IQ.

Part III: Results

In this section of the manuscript, I outline the major findings in the current study, which correspond to my central research aims. I begin by overviewing observed developmental trends, testing for effects of the intervention, and understanding individual differences.

It should be noted that the "best fitting" models described in the following chapters were selected using a forward stepwise regression technique on the basis of their adjusted R^2 (Nagelkerke). This is a measure of the total variance explained by the model similar to the R^2, and can be interpreted in the same way, but with the added benefit of being adjusted to correct for the number of predictors.

It should also be noted that in data tables, *M* and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation.

Chapter 9: Participants

This sample of participants featured 54 6 and 7-year-olds (M=7.09 years, SD=0.55; 42.6% boys) from the Twin Cities and the surrounding areas, and their parents. Demographic data indicated that the racial/ethnic diversity of the sample was greater than that of the Twin Cities (see Table 9.1). However, it is important to note that reliable and recent demographic data on *parents* and *children* from the Twin Cities area was not found. Thus, comparisons made between the study sample and the general TC population should be taken as only *rough* indicators of how representative this study sample is.

Parents. Examining parent education and family income, the sample was highly educated and affluent relative to the general population.

Parent Educational Attainment. About 82% of children had at least one parent with a bachelors' degree or higher, and about 14% had at least one parent with a doctorate (e.g. Doctorate, EdD) or professional degree (e.g. MD, JD). However, it should be noted that the available data on the general population was limited to adults over the age of 25, and we did not collect any data on parent age; thus, it is doubtful that samples are perfectly equivalent in terms of individuals' age. Furthermore, data on the general TC population indicates that there is a significant and sizable gender gap for educational attainment, with women being up to 20% more likely to have an Associate's, Bachelor's, or Master's degree (*note: the TC rate of doctorate and professional degrees is below 4%; thus, although men are about 45% more likely to have these degrees than women, the gender disparities here are differences of about 0.4%*). Although we did not collect data on parent gender, it was fairly evident to researchers that most of the parents who participated were women. Therefore, this may (at least partially) account for the large

disparity in educational attainment between the study sample and general population. Furthermore, it is unclear how our sample's parents compare to the subset of the general TC population who have children.

Table 9.1

Participant family educational attainment compared with that of general TC population.

	Twin Cities	Participants
Doctorate	3.9%	14.3%
Master's Degree	9.6%	32.7%
Bachelor's Degree	26.4%	34.7%
Associate's Degree	10.2%	14.3%
Some College	20.9%	4.1%
High School Diploma	22.1%	0%
Before High School Diploma	6.7%	0%

Table 9.2

Participant family income compared with that of general TC population.

	Twin Cities	Participants
95th percentile	232.9k	250k+
80th percentile	131.4k	140-179,999k
60th percentile	86.8k	100-139,999k
Median	70.9k	100-139,999k
40th percentile	56.4k	80-99,999k
20th percentile	30.8k	50-79,999k

Family Income. A staggering 100% of participating families had an annual income of at least $50,000, with about half making at least $100,000 annually. Thus, despite efforts to recruit diverse participants, a comparison of family income percentiles clearly indicates that children in the study sample come from more affluent families that

the general TC population. Again, it is unclear how our sample's parents compare to TC parents more generally.

Parent characteristics. Parent surveys were used to ascertain individual variation in epistemological judgments, authoritarian values, and need for cognition (Table 9.3). On average, parents were low in authoritarianism (M= 0.24 out of 1, SD= 0.27) and social conformity (M=0.25 out of 1, SD= 0.19). In contrast, Need for Cognition Scores, which ranged from -36 to 36, were moderately high (M= 15.81, SD= 11.51). As expected authoritarianism was highly correlated with social conformity (r =0.69, $p<0.01$), and *negatively* correlated with need for cognition (r =-0.33, $p<0.05$). The correlation between social conformity and need for cognition was marginally significant and negative, r= -0.26, $p=0.06$.

Parents also made 11 epistemological judgments in each of the domains of history and biology, with the number of absolutist, multiplist, and evaluativist responses added up into 3 separate scores for each domain. Parents' absolutist scores in history (range: 0-11; M=3.61, SD=2.58) and biology (range: 0-11; M= 6.26, SD= 3.20) were also used to calculate an Absolutist Total (range: 0 – 22; M= 9.87, SD=5.15). Similarly, multiplist scores in history (range: 0 – 11; M= 1.17, SD= 1.19) and Biology (range: 0-11; M= 0.26, SD= 0.68) were used to calculate a Multiplist Total (range: 0 – 22; M= 1.43, SD= 1.61); and evaluativist scores in history (range: 0 – 11; M= 5.96, SD=2.85) and biology (range: 0 – 11; M= 4.48, SD= 3.24) were used to calculate an Evaluativist Total (range: 0 – 22; M= 10.44, SD= 5.58).

Parent authoritarianism and social conformity were not significantly or marginally correlated with any measure of parent epistemological beliefs. In contrast, parent need for

cognition was marginally and negatively correlated with Multiplist Totals (r= -0.27, *p*=0.07). However, this finding should be taken with caution given the relatively low rate of multiplist responses.

There were no significant correlations between measures of socioeconomic status and authoritarianism, social conformity, or need for cognition. Furthermore, there was only one significant correlation between a measure of epistemological understanding and SES: parent educational attainment was positively correlated with the tendency to make evaluativist epistemological judgments, r= 0.286, p<0.05.

Table 9.3

Means, standard deviations, and correlations with confidence intervals (Spearman) for parent characteristics

Variable	*M*	*SD*	1	2	3	4	5
1. Authoritarianism (0 to 1)	0.24	0.27					
2. Social Conformity (0 to 1)	0.25	0.19	.69** [.51, .81]				
3. Need for Cognition (-36 to 36)	15.81	11.51	-.33* [-.55, -.06]	-.26 [-.50, .02]			
4. Total Absolutist Judgments (0 to 22)	9.87	5.15	.05 [-.22, .32]	.16 [-.12, .41]	-.02 [-.28, .25]		
5. Total Multiplist Judgments (0 to 22)	1.43	1.61	.04 [-.24, .30]	-.00 [-.27, .27]	-.25 [-.48, .02]	.05 [-.22, .31]	
6. Total Evaluativist Judgments (0 to 22)	10.44	5.58	-.09 [-.35, .18]	-.19 [-.44, .08]	.11 [-.16, .37]	-.94** [-.96, -.89]	-.33* [-.55, -.06]

Note. Values in square brackets indicate the 95% confidence interval for each correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Children. Children were 6 or 7 years old (M=7.09 years, SD=0.55, N=54). Almost half of the children were in 1st grade (47.37%), with the remaining participants in 2nd grade (31.6%) and kindergarten (21%). Over half of the participants were girls (~57.4%, N=31 girls).

Race/Ethnicity. With regards race/ethnicity, it should first be noted that comparison data from the general TC population includes people of all ages; furthermore, it excludes mixed-race and Hispanic individuals from the White/ Caucausian, Black/African/African-American, and Asian/Asian-American categories (The Demographic Statistical Atlas of the United States, 2018). However, due to the large number of mixed-heritage participants in the current study sample (~30%), the demographic diversity of the sample is best understood when these categories are not treated as mutually exclusive (Table 9.4).

For this sample, a vast majority of children reported being of European heritage (94.4%); however, only about 65% of children were of solely European heritage, which is below the general population. Put differently, almost all participants had at least one White parent or grandparent. Due in part to the high rate of mixed heritage backgrounds, the current sample features less children from ex Black/African-American backgrounds (~3.7%) than the general population (~ 7.8%); however, about 13% of children in our sample were of Black/ African-American heritage, which is far greater than the general population even if one were to assume that all mixed heritage individuals from the general population identified as Black/African American. A similar pattern emerges with other ethnic groups: no children were of solely Hispanic/Latino ethnicity; however, two

Hispanic/Latino children also belonged to one or more ethnic groups, as is common for Hispanic/Latino populations. The study sample also featured a number of participants of mixed Native American or Native Alaskan heritage (~4%), Asian heritage (~13%), and "Other" heritage (~4%; e.g. Persian, Arab, Pacific Islander).

Table 9.4

Children's racial/ethnic background compared with that of general TC population.

	Twin Cities (Mutually Exclusive)	Participants (Mutually Exclusive)	Participants (Non-Mutually Exclusive)
White Non-Hispanic	77.1%	64.8%	94.4%
Black Non-Hispanic	7.8%	3.7%	13%
Asian Non-Hispanic	6.2%	1.9%	13%
Hispanic	2.8%	0%	3.7%
Native American/ Native Alaskan	2.6%	0%	3.7%
Native Hawaiian / Pacific Islander	N/A	N/A	1.9%
Mixed Heritage	2.8%	29.6%	N/A
Other	0.7%	0%	3.7%

Note. Values in square brackets indicate the 95% confidence interval for each correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Cognitive Measures. In keeping with findings suggesting the study sample is not representative in terms of parent educational attainment and family income, children's executive function and verbal IQ scores were not representative of the national average for their age, with the mean MEFS score (M=110.13, SD= 8.67) being a standard deviation above the national average (M=100, SD= 10), and mean Verbal KBIT2 score (M= 120.02, SD = 16.61) being over two standard deviations above the national average (M=100, SD= 10). Unsurprisingly, age was correlated with grade (r= 0.88, p<0.001) and

verbal IQ (r= 0.29, p<0.05). Furthermore, executive functioning and verbal IQ were correlated, r= 0.38, p< 0.01 (Table 9.5).

Table 9.5

Means, Standard Deviations, and Correlations between cognitive measures and age

Variable	*M*	*SD*	1	2	3
1. Age (continuous)	7.09	0.55			
2. Grade	1.11	0.73	.87** [.77, .93]		
3. Verbal IQ	120.02	16.61	.26 [-.01, .50]	.24 [-.08, .52]	
4. Executive Functioning	110.13	8.67	.15 [-.13, .40]	.13 [-.20, .43]	.39** [.13, .60]

Note. Values in square brackets indicate the 95% confidence interval for each correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Parent-Child Intercorrelations. Examining intercorrelations among parent and child characteristics revealed that children's executive functioning was related to two parent characteristics. Parent need for cognition was marginally significantly correlated with children's MEFS scores (r= 0.24, p=0.09). Furthermore, parent social conformity—but not authoritarianism— was significantly negatively correlated with children's MEFS scores (r = -0.28, p= 0.05). However, this was no longer the case after controlling for parent need for cognition (r_p= -0.04, p= 0.77). Children's age, EF and IQ were not correlated with any other parent measures.

Table 9.6

Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4
1. MEFS (EF)	110.13	8.67				
2. KBIT2 (IQ)	120.02	16.61	.39** [.13, .60]			
3. Parent Need for Cognition	15.81	11.51	.24 [-.03, .48]	.16 [-.11, .42]		
4. Parent Authoritarianism	0.24	0.27	-.22 [-.47, .06]	-.22 [-.47, .06]	-.33* [-.55, -.06]	
5. Parent Social Conformity	0.25	0.19	-.27 [-.51, .00]	-.31* [-.54, -.04]	-.26 [-.50, .02]	.69** [.51, .81]

Note. Values in square brackets indicate the 95% confidence interval for each correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Chapter 10: Baseline Data

Calibration Trials. Across the three Calibration Trials of the Pretest, children were asked to make a prediction based on observed data and rate their own certainty on a 3-point-scale. Children indicated that they were "Very Sure" (M=1.1 out of 3, SD=0.82) about a third of the time, "Kinda Sure" (M= 1.40 out of 3, SD = 1.01) just under half of the time, and "Not So Sure" more rarely (M=0.60, SD=0.62).

An ANOVA analysis indicated that certainty levels occurred at significantly different rates, $F(2,53) = 55.41$, $p<0.001$, $\mu= 0.53$. Post-hoc analyses (Bonferroni corrected for multiple comparisons) revealed that children were "very sure" significantly less often than they were "kinda sure" (1.60 +/- 0.34) and "not so sure" (2.7 +/- 0.25). They were also "kinda sure" significantly more often than "not so sure" (1.10 +/- 0.14).

A score was calculated to represent the extent to which children's certainty was aligned with the strength of observed statistical evidence. Children were awarded a point if they were "very sure" in the 100% trial, "kinda sure" in the 75% trial, and "not so sure" in the 50% trio. Children were given partial credit in the form of half a point when they were "kinda sure" in the 100% trial, "not so sure" in the 75% trial, and "kinda sure" in the 50% trial. Points were totaled for each child's Calibration Score, which could range from 0 to 3 (M=1.05, SD=0.76).

Children were also asked to recall how many blocks were causally effective, as well as the certainty of speaker predictions. However, children made virtually no errors recalling block efficacy (M=0.001 errors out of 3, SD=0.09), and made very few errors regarding the Calibrator's statements (M= 0.11 out of 3, SD= 0.31) and Overconfident

speaker's statements (M= 0.04 out of 3, SD= 0.19).

Table 10.1

Correlations Among Children's Explicit Judgments of Speakers

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Best (C)	0.98	0.84								
2. Best (O)	0.31	0.61	-.40** [-.60, -.14]							
3. Best (B)	1.07	0.95	-.31* [-.53, -.04]	-.01 [-.28, .26]						
4. Know (C)	0.52	0.50	.61** [.40, .75]	-.48** [-.66, -.24]	-.20 [-.44, .07]					
5. Know (O)	0.39	0.49	-.40** [-.60, -.14]	.59** [.38, .74]	.18 [-.09, .43]	-.83** [-.90, -.72]				
6. Know (B)	0.02	0.14	-.16 [-.41, .11]	-.07 [-.33, .20]	.28* [.01, .51]	-.14 [-.40, .13]	-.11 [-.37, .16]			
7. Like (C)	0.45	0.50	.20 [-.07, .45]	.02 [-.25, .29]	-.13 [-.39, .14]	.33* [.06, .55]	-.16 [-.41, .11]	-.13 [-.38, .15]		
8. Like (O)	0.23	0.42	-.20 [-.45, .07]	.31* [.04, .53]	-.05 [-.32, .22]	-.39** [-.60, -.14]	.42** [.16, .62]	-.08 [-.34, .20]	-.49** [-.67, -.26]	
9. Like (B)	0.15	0.36	-.12 [-.38, .16]	-.14 [-.39, .14]	.41** [.15, .61]	-.02 [-.29, .25]	-.11 [-.37, .16]	.33* [.06, .55]	-.38** [-.59, -.13]	-.23 [-.47, .04]

Children's evaluations of speaker reasoning were also analyzed (Figure 10.1). After each trial participants were asked "Who has the best way of thinking?" (Figure 10.1). Some children chose the Overconfident speaker (M=0.31 out of 3, SD=0.61), but many chose the Calibrator (M= 0.87 out of 3, SD= 0.9), or "both" (M= 1.07 out of 3, SD= 0.95). An ANOVA analysis revealed that children chose speakers at significantly different rates, $F(2, 53) = 11.49$, $p<0.001$, $\mu= 0.18$.

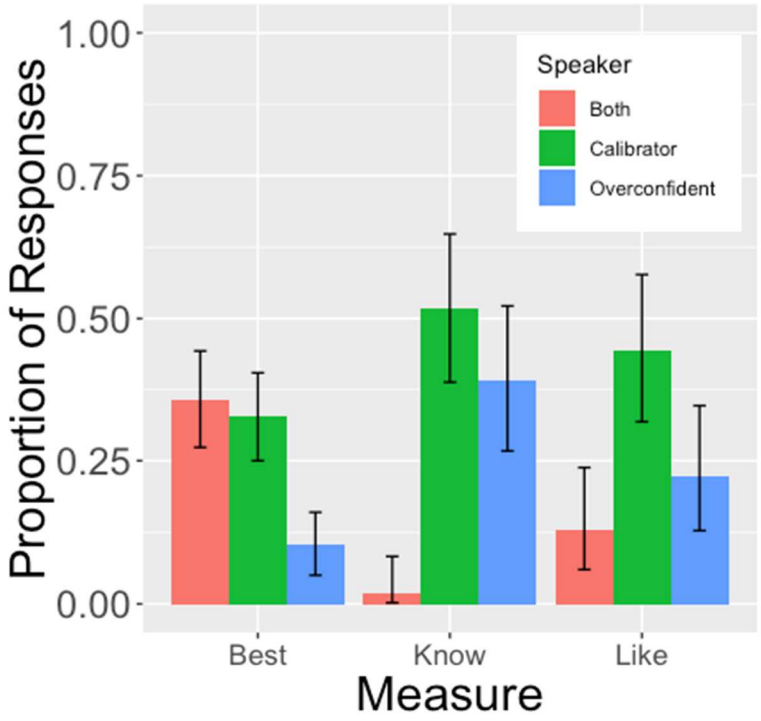

Figure 10.1. Children's explicit judgments of speakers at baseline

Post-hoc analyses (Bonferroni corrected for multiple comparisons) revealed that children were significantly more likely to say the Calibrator had the "best way of thinking" compared to the Overconfident speaker (0.67 +/- 0.17), and significantly more likely to say both speakers had the "best way of thinking" compared to just the Overconfident speaker (0.76 +/- 0.15).

After the 3 trials, children were asked which of the two speakers they believed "knows more", with about half choosing the Calibrator (M= 0.52 out of 1, SD=0.5), and most others choosing the Overconfident speaker (M= 0.39, SD=0.49). An ANOVA analysis revealed that children's attributions of knowledge for the Calibrator and Overconfident speaker were not significantly different, p= 0.97.

Children were also asked which of the two speakers they liked more. The Calibrator was chosen most often (M= 0.44 out of 1, SD= 0.5), followed by the Overconfident speaker (M = 0.22, SD= 0.42). A substantial fraction of children refused to pick just one, and indicated they liked "both" (M= 0.17, SD = 0.42). An ANOVA analysis revealed that children provided these three categories of responses at significantly different rates, $F(2, 53)= 4.27$, p=0.02, μ=0.07. Specifically, post-hoc analyses (Bonferroni corrected for multiple comparisons) revealed that children were significantly more likely to say they liked the Calibrator rather than say they liked both speakers equally (0.278 +/- 0.10). However, children did not like the Calibrator and Overconfident speaker at significantly different rates. Likely due to the low rate of memory errors, there was no significant relation between children's memory of events and their explicit judgments about speakers, ps>0.05.

Intercorrelations. Children's Calibration Scores (Table 10.2) were not correlated with age, EF or IQ; however, they were *negatively* correlated with their tendency to say they liked "both" speakers (r= -0.32, p<0.05), and that "both" speakers "know more" (r= -0.28, p<0.05). Thus, children who were poorly calibrated were less likely to discriminate between speakers on the basis of their perceived knowledge or likeability.

Table 10.2

Means, standard deviations, and correlations with confidence intervals for calibration scores

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Age	7.09	0.55							
2. Sex	0.42	0.50	-.02 [-.29, .25]						
3. EF (MEFS)	110.13	8.67	.15 [-.13, .40]	-.34* [-.56, -.07]					
4. IQ (KBIT 2)	120.02	16.61	.26 [-.01, .50]	-.11 [-.37, .17]	.39** [.13, .60]				
5. Calibration Score	1.67	0.62	-.03 [-.29, .24]	.02 [-.26, .29]	.15 [-.12, .41]	-.08 [-.34, .20]			
6. EJT Composite (C)	0.65	0.48	.18 [-.09, .43]	-.09 [-.35, .19]	.13 [-.15, .39]	-.22 [-.46, .06]	.29* [.03, .52]		
7. EJT Composite (O)	0.38	0.36	-.22 [-.47, .05]	.17 [-.11, .42]	-.11 [-.37, .17]	-.04 [-.31, .24]	.02 [-.25, .29]	-.22 [-.46, .06]	
8. EJT Composite (B)	0.52	0.35	-.14 [-.40, .13]	-.01 [-.28, .26]	.16 [-.12, .41]	.00 [-.27, .28]	.06 [-.21, .33]	-.02 [-.29, .25]	.19 [-.08, .44]

Note. Values in square brackets indicate the 95% confidence interval for each correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Children's tendency to credit the "best way of thinking" to the Calibrator was correlated with a number of measures. As expected, it was strongly positively correlated with their crediting the Calibrator with "knowing more" (r= 0.61, $p< 0.01$); negatively correlated with saying the Overconfident speaker had "the best way of thinking" (r= -0.40, $p< 0.01$) and knew more (r= -0.40, $p< 0.01$); and negatively correlated with saying

both speakers had the "best way of thinking" (r= -0.31, $p< 0.05$). Along these lines, children's tendency to say the Calibrator "knows more" was also positively correlated with liking her more (r= 0.34, $p<0.05$). Furthermore, children's overall composite score for the calibrator was positively correlated with children's own calibration scores, r= 0.29, $p<0.05$. Thus, children who showed a preference for the Calibrator were more likely to be well-calibrated themselves.

Interestingly, children's executive functioning skills were *negatively* associated with their tendency to preferentially like the Overconfident speaker, r= -0.37, $p<0.01$. Furthermore, a few sex differences were noted: boys tended to have *lower* EF Scores than girls (r= -0.34, $p< 0.05$), and were *more* likely to indicate that Overconfident speaker has "best way of thinking" (r = 0.28, $p< 0.05$), and say that they liked her more (r = 0.28, $p< 0.05$). However, boys' preferences for the unjustifiably certain speaker disappeared after controlling for MEFS scores. Thus, while it may be that boys tend to prefer overconfident speakers more than girls, this is likely because these preferences are negatively associated with EF skills.

These results are, for the most part, in line with the hypothesis that children's ability to make critical evaluations of speakers on the basis of their calibration rests, in part, on cognitive control (e.g. working memory, task switching, inhibition). However, there was no significant relation between children's overall preference for the Overconfident speaker (composite score) and their EF skills, r= -0.11, $p>0.05$.

Interim Summary

A composite score was calculated to reflect the proportion of times (out of 5) that

children displayed a preference for the Calibrator, Overconfident speaker, or Both (Figure 10.2). An ANOVA analysis revealed a significant effect of speaker on children's judgments, $F(2, 51)= 4.99$, $p=0.01$, partial $eta^2= 0.16$. Post-hoc analyses (Bonferroni corrected for multiple comparisons) revealed that children chose the Calibrator significantly more often than the Overconfident speaker (+/-0.208, $p<0.01$), and marginally more often than "both" speakers, (+/-0.14, $p=0.07$). Thus, to summarize, children were not particularly impressed by the Overconfident speaker; however, a significant subset of children did not discriminate between the two, choosing "Both".

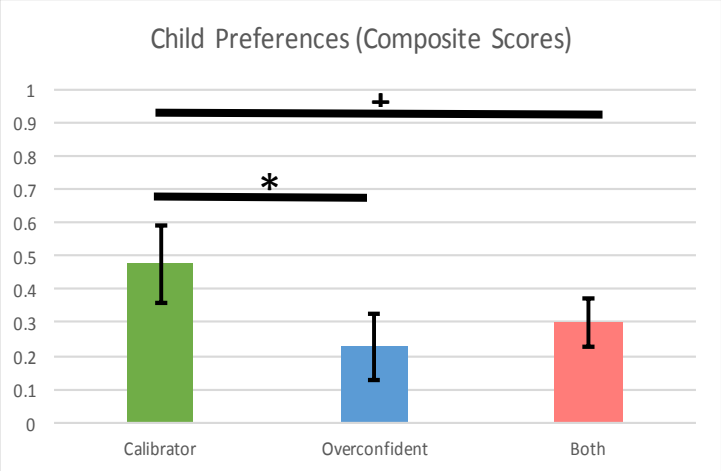

Figure 10.2. Children's Explicit Judgments of Reasoners at Baseline (Composite Scores)

Furthermore, results would suggest that EF may play a role in children's preferences, as lower EF skills are associated with a personal, social preference for the Overconfident speaker ("Like"). However, these results are not fully in line with the hypothesis that executive functions (e.g. inhibition) are involved in speaker evaluations, as there was no direct link between EF and children's epistemic evaluations ("best thinking", "knows more"). However, the correlation between calibration scores and preference for the

Overconfident speaker does suggest that children's own ability to adjust their beliefs in line with evidence is relevant to their judgments of others' ability to do so**.**

Table XX: Associations Between Composite EJT Scores and Child Measures

Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Calibrator	0.98	0.84							
2. Overconfident	0.31	0.61	-.40** [-.60, -.14]						
3. Both	1.07	0.95	-.31* [-.53, -.04]	-.01 [-.28, .26]					
4. Age	7.09	0.55	.16 [-.11, .41]	-.19 [-.44, .08]	-.14 [-.39, .13]				
5. Sex	0.42	0.50	.02 [-.25, .29]	.28* [.01, .51]	.13 [-.14, .39]	-.02 [-.29, .25]			
6. MEFS	110.13	8.67	.03 [-.24, .30]	-.24 [-.48, .03]	-.01 [-.28, .26]	.15 [-.13, .40]	-.34* [-.56, -.07]		
7. IQ	120.02	16.61	-.16 [-.41, .12]	-.03 [-.30, .25]	.08 [-.20, .35]	.26 [-.01, .50]	-.11 [-.37, .17]	.39** [.13, .60]	
8. Calibration Score	1.67	0.62	.22 [-.05, .46]	-.19 [-.44, .08]	-.05 [-.32, .22]	-.03 [-.29, .24]	.02 [-.26, .29]	.15 [-.12, .41]	-.08 [-.34, .20]

Note. *M* and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates $p < .05$. ** indicates $p < .01$.

Vignettes. Throughout the three vignettes, children correctly indicated that the characters disagreed rather than agreed about the topic (M= 2.83 out of 3, SD=0.42) at rates significantly greater than chance, $p<0.05$. Thus, as a group, children not only understood the meaning of the word "disagree", but were able to successfully recognize a disagreement between two speakers.

Making sense of disagreements. When asked if it made sense that there would be disagreement about the topic, on average children said "yes" most of the time (M=1.81 out of 3 trials, SD=1.07), "no" about a third of the time (M=1.09 out of 3 trials, SD= 1.09), and almost never said "maybe" (M= 0.02 out of 3 trials, SD=0.14). A paired t-test indicated that children were significantly more likely to indicate that it would "make sense" to disagree about the topic as opposed to "not make sense", $t(53)= 2.5$, $p=0.01$, $d= 0.34$. This suggests that children are aware of, and understand, diverging perspectives.

Figuring it out. When asked if they believed the characters might need help to figure out the issue, about two-thirds of responses were "yes" (M= 2.02 out of 3, SD= 0.86). This would suggest that a majority of children recognized that the disagreement was regarding a matter that could theoretically be figured out. Among children who indicated help was needed, children agreed it was possible that one of the characters could need more help than the other roughly half the time (M= 1.43 out of 3, SD=1.01). Thus, among children who recognized the disagreement as concerning a knowable truth, about half of these children acknowledged that the disagreement may be explained by the characters' differing abilities to access or establish what is true. That is, about a third of the time children not only viewed truth as knowable, but were under the impression that

differences in people's ability to construct or access knowledge could explain diverging perceptions of truth.

Children who offered suggested methods for "figuring out" the disagreed-upon matter were then asked if their suggested approach could lead to "knowing for sure" (Table 10.4). A common suggestion to "figure it out" was to ask someone. Binomial analyses revealed that for objective matters of fact, children were significantly more likely to say that asking an expert would result in knowing for sure than not knowing for sure, $p<0.05$. This could not be determined for the Integrated and Subjective domains due to low sample sizes of children having suggested asking an expert as a means to "figure it out". Additionally, children did not systematically indicate whether asking a non-expert (such as a parent) or other person (e.g. asking the coach if he is nice or mean) would lead to knowing for sure.

Children who suggested turning to reference materials to "figure it out" were significantly more likely to indicate that "looking it up" would not necessarily lead to "knowing for sure" in the Objective and Integrated domains. Only two children suggested "looking it up" for Subjective issues, and only one of these suggested it would lead to "knowing for sure". A few children suggested polls or "other" means (e.g. "rock, paper, scissors") to "figure it out"; however, sample sizes were too small to determine whether their judgments of the certainty of knowledge derived from these means were systematic.

In sum, children suggested a diverse array of means to "figure out" the matter being discussed. Generally they varied in their assessment of the certainty of knowledge derived from such means. However, children who suggested seeking an objective truth

from expert testimony were significantly more likely to say that this would lead to "knowing for sure", rather than not. Similarly, children who suggested investigation, tests or observation as a means to "figure it out" were significantly more likely to say it would lead to certain, rather than uncertain, knowledge in the Integrated domain. In contrast, children who suggested "looking it up" in a book, online, or via a digital assistant (e.g. Siri)—which occurred primarily for the Objective and Integrated domains— were significantly more likely to say that it would not lead to certain knowledge.

Table 10.4
*Percentage of children in each vignette type who indicated that one could know for sure for suggested means. Analyses run due to sufficient sample size are in **bold** text.*

Means	Objective		Integrated		Subjective	
	%	N	%	N	%	N
Ask Expert	**83****	**23**	25	4	100	3
Ask Non-Expert	25	8	44	9	33	3
Ask Other	43	7	75	4	**54**	**13**
Discuss	N/A	0	0	1	N/A	0
Look Up	**26*****	**50**	**0*****	**36**	50	2
Investigate	40	5	**77***	**13**	56	9
Poll	N/A	0	0	1	0	1
Other	83	6	40	5	59	2

Note. Binomial tests indicate whether children indicated one could "know for sure" above chance. * indicates $p < .05$. ** indicates $p < .01$.

Nature of truth. Finally, children were asked to consider the conflicting claims made in the vignette in terms of their possible truth value: "Does someone here have to be wrong, or could they both be right? [If both] Could one of them be more right than the other, or not really?". Chi-Squared tests indicated that children were significantly more likely to indicate that someone had to be wrong in the Objective vignettes than the Subjective or Mixed, $X^2= 9.33$, $p<0.001$; significantly more likely to indicate that speakers could both be right and one couldn't be more right than the other in the Subjective Vignettes than the Objective or Mixed, $X^2= 28.0$, $p<0.001$; and significantly more likely to indicate that both speakers could be right, but one could be more right than the other in the Mixed Vignettes than the Objective or Subjective, $X^2= 20.28$, $p<0.001$. Thus, children's judgments about the truth value of conflicting claims are sensitive to the nature of the disagreement.

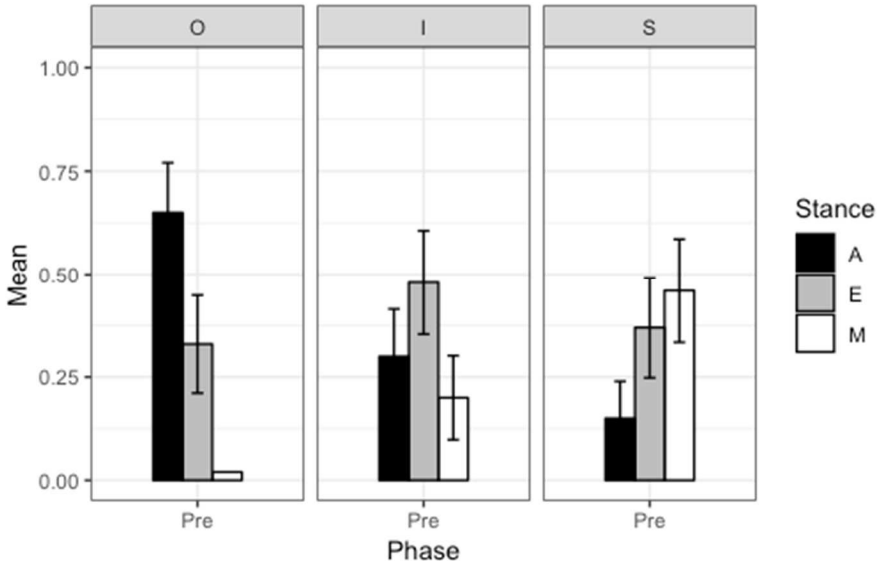

Figure 10.3. Children's epistemological stances at baseline suggest that even prior to an intervention, their epistemological beliefs and reasoning is diverse, flexible, and context-dependent (bars represent standard errors).

Stance. Children adjusted their epistemological stance by vignette (Figure 10.3). Chi squared tests indicated that within the objective domain, Absolutism was significantly more prevalent than Evaluativist or Multiplist perspectives; furthermore, Evaluativism was significantly more common than Multiplism in this domain, *ps*<0.05. Multiplism was significantly more common than Absolutism in the Subjective domain, *p*<0.05. However, Evaluativism did not occur at rates significantly different from the other two perspectives in this domain, *ps*>0.05. Finally, Evaluativism was significantly more common than multiplism common in the Integrated domain, *p<0.05*; however, Absolutism did not occur at rates significantly different from Evaluativism or Multiplism in this domain, *ps*>0.05.

A series of three one-way-ANOVA analyses did not reveal any significant main effects of age on children's overall tendency to make Absolutist, Multiplist, or Evaluativist Judgments across the three vignettes (Table 10.5).

Table 10.5

Results from three one-way ANOVA analyses examining the effects of age on children's total Absolutist Judgments, Multiplist Judgments, and Evaluativist Judgments

Model	Stance	Predictor	*df*	*SS*	*F*	*p*	Fit
1	Absolutist	Age	1	0.27	0.25	0.62	R^2 = .005
2	Multiplist	Age	1	0.88	1.85	0.18	R^2 = .034
3	Evaluativist	Age	1	0.0031	0.0033	0.95	R^2 = .000

Note. * indicates $p < .05$. ** indicates $p < .01$.

A series of three Mixed Effects Binary Logistic Regression models were conducted to assess the effects of age, vignette type, and age-by-vignette type interactions on children's absolutist, multiplist, or evaluativist judgments (Table 10.5). Mauchly's test

did not indicate any violations of the sphericity assumption, so no corrections were made.

Table 10.6`

Children's Absolutist Judgments at Baseline (Fixed Effects)

Predictor	*b*	*SE*	*p*	Fit
(Intercept)	-7.142***	0.01	<.001	
Age: Objective	10.40***	0.01		
Age: Integrated	8.11***	0.01	<.001	
Age: Subjective	6.82***	0.01	<.001	
				Nagelkerke R^2=0.51**

Note. * indicates $p < .05$. ** indicates $p < .01$.

Absolutist Judgments at Baseline. A mixed-effects binary logistic regression model revealed no significant main effect of Age or Vignette Type on Absolutist Judgments, *ps*>0.5. However, there was a significant and large Age-by-Vignette Type interaction effect, F(2, 53)=5.04, $p<0.001$, partial eta^2= 0.34. That is, the effects of age on children's tendency to make Absolutist Judgments varied significantly as a function of Vignette Type.

Post-hoc analyses (Tukey's HSD; see Table 10.7) indicate that older children were significantly more likely to make Absolutist Judgments in the Objective scenario compared to both the Integrated ($p<0.001$) and Subjective ($p<0.001$) vignettes. Furthermore, older children were significantly more likely to make Absolutist Judgments in the Integrated scenario compared to the Subjective, ($p<0.001$). Although results from the overall ANOVA suggest that older children do not make more Absolutist Judgments overall, this mixed-effects model does suggest that with age, Absolutist epistemological reasoning is more likely observed in situations that are relatively objective. Put

differently, it seems that older children's absolutism is more flexible or sensitive to context than younger children's.

Table 10.7

Estimated Marginal Means (Tukey's HSD) for Absolutist Judgments at Baseline

Contrast	estimate	*SE*	*p*
Objective - Integrated	17.44 ***	2.74	<.001
Objective - Subjective	26.48 ***	4.03	<.001
Integrated - Subjective	9.05***	1.86	<.001

Note: Results are given on the log odds ratio (not the response) scale. P value adjustment: Tukey method for comparing a family of 3 estimates.

Multiplist Judgments at Baseline. A mixed-effects binary logistic regression model revealed no significant main or interaction effect of age on children's Multiplist Judgments. However, there was a medium and significant main effect of Vignette Type, $F(2, 53)= 9.66$, $p<0.001$, partial $eta^2= 0.35$.

Table 10.8
Children's Multiplist Judgments at Baseline (Fixed Effects)

Predictor	*b*	*SE*	*p*	Fit
(Intercept)	-8.12*	3.51	<.001	
Integrated	2.71*	1.08	<.05	
Subjective	4.08***	1.11	<.001	
Age	2.8*	0.46	<.05	
				R^2=0.14***

Note. df_{Num} indicates degrees of freedom numerator. df_n indicates degrees of freedom. R^2 indicates Nagelkerke pseudo R squared.

Post-hoc analyses (Tukey's HSD; see Table 10.9) indicate that children were significantly less likely to make Multiplist Judgments in the Objective scenario compared

to the Integrated and Subjective scenarios. They were also significantly less likely to make Multiplist Judgments in the Integrated scenario compared to the Subjective. Thus, children—regardless of age—were generally more likely to make Multiplist epistemological judgments as a function of the perceived subjectivity of the discussion.

Table 10.9

Estimated Marginal Means (Tukey's HSD) for Multiplist Judgments at Baseline

Contrast	estimate	*SE*	*p*
Objective - Integrated	-2.71 *	1.08	<.05
Objective - Subjective	-4.08 ***	1.11	<.001
Integrated - Subjective	-1.37 *	0.51	<.05

Note: Results are given on the log odds ratio (not the response) scale. P value adjustment: Tukey method for comparing a family of 3 estimates.

Evaluativist Judgments at Baseline. A mixed-effects binary logistic regression model revealed no significant main or interaction effect of Age on Evaluativist Judgments, *ps*>0.5. Interestingly, Integrated Vignette Type was marginally significantly predictive of children's Evaluativist Judgments. However, the overall model featuring Vignette Type as a predictor was not significant.

Table 10.10

Children's Evaluativist Judgments at Baseline (Fixed Effects)

Predictor	*b*	*SE*	*p*	Fit
(Intercept)	0.06	0.34	.98	
Objective	-.70	0.44	*ns*	
Subjective	-.52	0.43	*ns*	
Age	-0.02	0.37	*ns*	
				R^2=0.05

Note. df_{Num} indicates degrees of freedom numerator. df_n indicates degrees of freedom. R^2 indicates Nagelkerke pseudo R squared.

Notably, nearly 40% of children held evaluativist perspectives in the subjective domain, despite work indicating that even adults struggle to acknowledge how matters of taste can be evaluated based on some objective criteria (e.g. judging music based on pitch; Kuhn, et al. 2000). Importantly, baseline results indicate that children's epistemological understanding is diverse, context-dependent, and at times highly sophisticated.

Chapter 11: Intervention

Throughout the three Intervention Phase vignettes, some of children's responses changed significantly compared to the pretest.

Making Sense of Disagreements. Paired t-tests indicated that the discussed disagreements "made sense" to children at similar rates to the baseline phase, $p=0.46$. However, there was a marked decrease in the number of children who said that it did not make sense to disagree about the topic, $t(54)= 1.22$, $p=0.01$; and an increase in the number of children who said that it maybe made sense $t(54)=-2.8$, $p=0.007$. Thus, children who had previously indicated that the disagreement in the vignettes did *not* make sense were increasingly ambivalent about this in the Intervention Phase.

Figuring it out. Paired t-tests indicated that there was a significant increase in the number of times children indicated that the characters would need help to figure out the disagreement ($p=0.05$). Thus, in the intervention phase an even larger majority of children recognized that the disagreement was regarding a matter that could theoretically be figured out.

Nature of truth. Children's considerations of the truth value of conflicting claims differed significantly from the Pretest Phase. Children were significantly *less* likely to say someone had to be wrong, and significantly *more* likely to say that both could be right, with one being more so than the other, $t(54)= 1.14$, $p<0.001$. The proportion of children who indicated that both speakers could be equally, but not relatively, right was not significantly different.

Epistemological Stance. Along these lines, children's epistemological stances

were significantly different from baseline in the Intervention Phase. Paired t-tests indicate that overall, absolutist judgments were significantly reduced, t(54)=2.98, p=0.004; multiplists judgments were significantly reduced, t(54)= 2.82, p=0.007; and as intended, evaluativist judgments increased significantly, t(54)= -4.54, p<0.001.

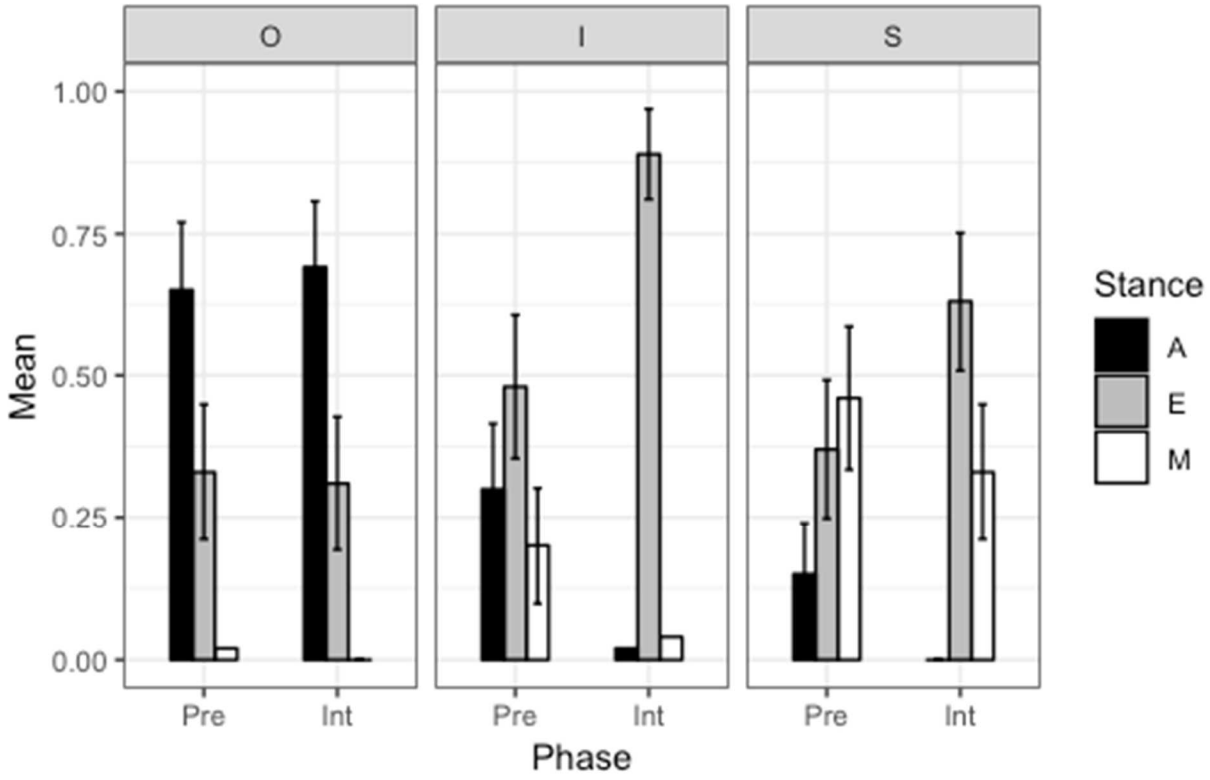

Figure 11.1. Proportion of Children's Epistemological Judgments by Phase.

Engagement. Children's engagement for each vignette (Objective: M= 1.15 out of 2, SD= 0.57; Mixed: M= 1.37, SD= 0.64; Subjective: M= 1.40, SD = 0.61) was generally moderate-to-high. Furthermore, their total engagement (M= 4.02 out of 6, SD= 1.39), was significantly greater than chance, t(45)= 4.934, p<0.001. Furthermore, evidence confirms that the effectiveness of the intervention was a function of child engagement. For example, engagement in the objective vignette was negatively

correlated with taking an absolutist stance in this domain (r= -0.314, $p<0.05$), and an evaluativist stance (r= 0.333, p<0.05). Similarly, engagement in the Mixed vignettes was negatively correlated with taking an absolutist (r= -0.214, p<0.05) or multiplist stance (r= -0.284, p<0.05) in this domain, and positively correlated with an evaluativist stance (r= 0.530, p<0.05). Furthermore, engagement in the Subjective vignettes was negatively correlated with multiplist stances in this domain, (r= -0.386, p<0.05), and positively correlated with evaluativist stances (r= 0.39, p<0.05).

Engagement was also positively correlated with children's tendency to suggest testing, observation and investigation as a means to "figure out" disputes in the Subjective domain (r=0.373, p<0.05). Overall engagement was also correlated an *increase* in children's assertion that disagreements did not make sense between the pretest and intervention, r= 0.32, p<0.05; and a *decrease* in children's assertion that both speakers could be right, but not more so than the other, r -0.349, p<0.05.

Engagement was also correlated with responses in the Pretest calibration trials. For example, children who had more frequently indicated that "both" reasoners had the best way of thinking were generally less engaged in the Intervention Phase, r= -0.34, p<0.05. Similarly, children who had more frequently indicated that the overconfident reasoner had the best way of thinking were generally less engaged in the Intervention's Objective vignette, r= -0.36, p<0.05. Thus, children who had found the Overconfident reasoner to be equally or more competent than her well-Calibrated counterpart were not as prone to accepting or elaborate upon the experimenters' evaluativist epistemological scaffolding later on.

Notably, children's engagement in the intervention phase was unrelated to child sex, family demographic factors, child cognitive skills (EF and IQ), and parent factors including parent epistemological understanding, authoritarian values, social conformity, and need for cognition. However, it was correlated with child age, such that older children were more engaged, $r= 0.33$, $p<0.05$.

Chapter 12: Experimental Results

In this chapter, we test the effects of the epistemological intervention on children's informal critical thinking (calibration trials) and their epistemological understanding (vignettes).

Calibration. As in the Pretest, for each Posttest calibration trial, children were asked to make a prediction based on observed data and rate their own certainty on a 3-point-scale. After the intervention, children were significantly less likely to indicate that they were "very" sure ($M=0.51$ out of 3, $SD= 0.11$), $t(53)= 8.33$, $p<0.001$. In contrast, children were significantly more likely to say they were "not so" sure ($M= 1.22$ out of 3, $SD=0.69$), $t(53) = -7.67$, $p<0.001$.

As in the Pretest Phase, a score was calculated to represent the extent to which children's certainty was aligned with the strength of observed statistical evidence. Children were awarded a point if they were "very sure" in the 100% trial, "kinda sure" in the 75% trial, and "not so sure" in the 50% trial. Children were given partial credit in the form of half a point when they were "kinda sure" in the 100% trial, "not so sure" in the 75% trial, and "kinda sure" in the 50% trial. Points were totaled for each child's Calibration Score, which could range from 0 to 3 ($M=1.14$, $SD=0.15$). Despite changes in the frequency of "very sure" and "not so sure" responses, the children's calibration scores were not significantly different after the intervention, $t(53)= 0.57$, $p= 0.6$. This suggests that although children were less certain in the posttest, this was a general effect not due to an increased sensitivity to the statistical data.

Children's evaluations of speaker reasoning were also analyzed as in the Pretest.

After each trial participants were asked "Who has the best way of thinking?". Although children did not select the Calibrator or Overconfident speaker at significantly different rates, a paired t-test indicated children were significantly more likely to indicate that "both" had the best way of thinking in the Posttest than they did in the Pretest, $t(53)= 2.604$, $p<0.05$. Similarly, related samples chi-squared analyses revealed that children were not significantly different in their indications that the Calibrator, Overconfident or Both speakers knows more; or that they liked the particular speaker more or less after the intervention, *ps*>0.05.

Vignettes. Paired t-test analyses were used to assess whether there were significant differences in children's responses to the vignette questions after the intervention. Overwhelmingly, children's responses did not vary significantly from those at pretest, with one exception: children were significantly more likely to suggest asking an expert at posttest, $t(53)= 2.84$, $p<0.01$. After the intervention, children were also marginally more likely to say that the disagreement did *not* make sense, $t(53)= 1.81$, $p=0.08$.

Epistemological Stance. Although the intervention significantly reduced absolutist judgments and increased evaluativist judgments in real time, these effects did not appear to carry over into the posttest phase (Figure 12.1). Betwee pre- and posttest, there was no siginificant difference between childrens' absolutist judgments, $t(53)=0.98$, $p=0.4$; multiplist judgments, $t(53)=-0.63$, $p=0.5$; or evaluativist judgments, $t(53)=1.23$, $p=0.2$.

Cognitive Factors. In order to better understand whether individual differences in children's executive functioning and/or verbal IQ were related to the effects of an epistemological intervention on their learning, each target measure in the Calibration and

Vignette trials was used to calculate a Delta score. This score represented the individual child's differential response in the Pretest and Posttest on each given measure, with a positive score representing an intervention-related *increase*, and a negative score representing a *decrease*.

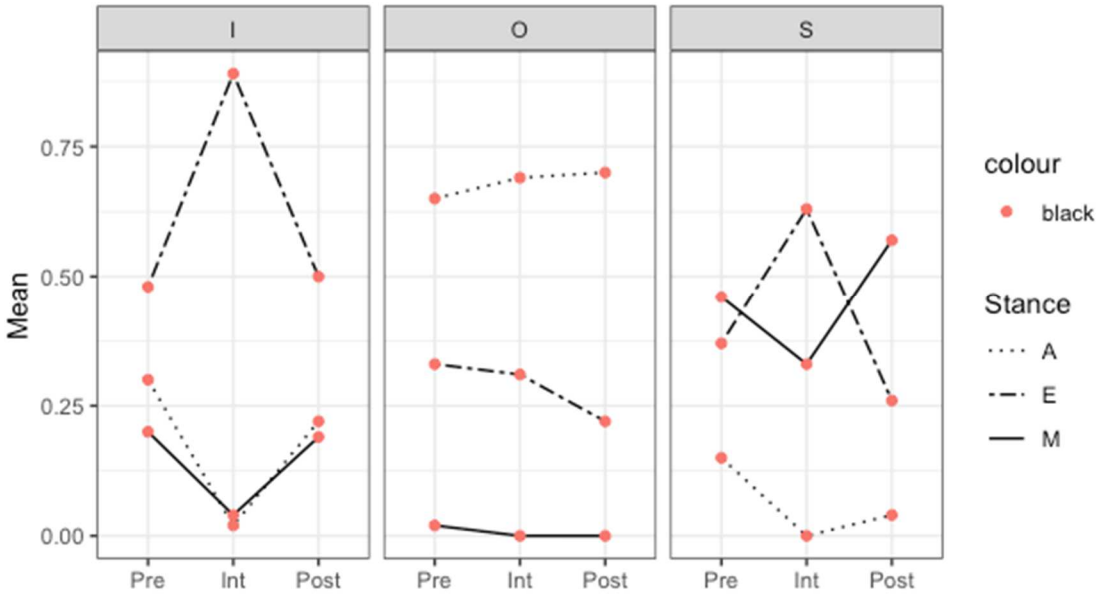

Figure 12.1. Intervention (1) significantly reduces absolutist judgments; (2) increases evaluativist judgments, and has no significant effect on multiplist judgments; however, its effects to do not carry over into the post-test.

For the most part, effects of the intervention were unrelated to cognitive factors. However, children's IQ was positively correlated with an increase in children's acknowledgement in the vignette trials that although both speakers could be right, one could be "more right" than the other, r= 0.28, p=0.04. Children's IQ was also marginally significantly correlated with an increase in children's acknowledgement that the Calibrator "knows more", r= 0.25, p=0.07.

To assess the predictive power of IQ after controlling for EF, linear regression models featuring both covariates were run. Verbal IQ had a unique, small, and marginally

significant effect on children's increased tendency to say that two disagreeing speakers could be right, but one could be "more right", post-intervention, $F(1, 53)= 3.22$, $p=0.07$, partial $eta^2= 0.06$. Similarly, Verbal IQ had a unique, small, and marginally significant effect on children's increased tendency to credit the Calibrator with more knowledge post-intervention, $F(1, 53)= 3.62$, $p=0.06$, partial $eta^2= 0.05$.

Engagement. Perhaps surprisingly, children's engagement levels in the Intervention phase were unrelated to any epistemological changes between the Pretest and Posttest phases. They were also unrelated to any changes in children's responses during the Calibration trials.

Chapter 13: Individual Differences in Calibration and Judgments Thereof

What factors predict individual differences in children's learning and epistemological stances? In this chapter I overview the models that theoretically and actually account for the most variance in the observed data at baseline, as well as the observed effects of the intervention.

Individual Differences in Children's Calibration

Predictors for the theoretical model of children's own calibration include child age, parent factors (need for cognition), epistemological factors (children's evaluativism) and cognitive factors (MEFS). However, none of these factors was a significant predictor of individual differences in children's calibration, and the overall model accounted for only about 5% of observed variance (Figure 13.1).

Table 13.1

Summary of Theoretical Regression Model for Children's Calibration Score (N = 54)

Predictor	*b*	*r*	Fit
(Intercept)	0.87		
Age	-0.05	-.03	
Parent Need for Cognition	0.01	.13	
Child Evaluativism	-0.08	-.11	
EF (MEFS)	0.01	.15	
			Nagelkerke R^2 = .050

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

The model that best explained children's ability to adjust their own certainty in response to the data was similar. If featured parent education, parent need for cognition,

parent absolutism, and executive functioning. Overall, this model explained about 49% of the variance in children's calibration scores.

Table 13.2

Summary of Best Fitting Regression Model for Children's Calibration Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	-1.39	.62	
Parent Education	.60***	.07	
Parent Need for Cognition	.13**	.004	
Parent Absolutism	-.33***	.001	
EF (MEFS)	.20***	.005	
			Nagelkerke R^2 = .49*

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Children whose parents' had a high educational attainment were significantly more likely to adjust the certainty of their predictions in accordance with the strength of observed statistical data. Similarly, well-calibrated children were significantly more likely to have parents with a high need for cognition, or a tendency to enjoy engaging in effortful thinking and problem-solving. Furthermore, well-calibrated children were significantly less likely to have absolutist parents, and significantly more likely to have stronger executive functioning skills.

Preference for Calibrator. Predictors for the theoretical model of children's preference for the Calibrator (composite score) include parent factors (evaluativism, authoritarianism, need for cognition) as well as children's personal (Age) and cognitive factors (EF, IQ). This model accounted for about 19% of the observed variance (Table 13.3).

Table 13.3

Summary of Theoretical Regression Model for Calibrator Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	-0.11		
IQ	-0.01	.02	
MEFS	0.02	.01	
N4C	-0.00	.02	
Authoritarianism	0.11	.04	
Parent Evaluativism	-0.02	.13	
Child Evaluativism	-0.10	.17	
Age	0.62^{+}	.17	
			Nagelkerke R^2 = .193

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation. * indicates $p < .05$. ** indicates $p < .01$.

Instead, the model that best fit the data (about 27% of the variance explained), featured parent factors (parent multiplism) as well as children's epistemological (Absolutism at baseline), personal (Age) and cognitive factors (EF). Although age and EF were individually marginally significant, together these factors contributed significantly to the model. The model suggests that children who preferred the Calibrator tended to be older, had better executive functioning skills, made fewer absolutist judgments, and had parents who made more multiplist judgments.

Examining children's preference for the overconfident speaker, the theoretical model again included parent factors (absolutism, authoritarianism, need for cognition) as well as children's personal (age), epistemological (absolutism) and cognitive factors (EF, IQ). The theoretical model explained about 20% of the variance in children's preference for the Overconfident speaker, and suggested that children's absolutism and age were good predictors.

Table 13.4

Summary of Best Fitting Regression Model for Calibrator Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
Age	0.21^{+}	.02	
MEFS Score (EF)	0.30^{+}	.12	
Parent Multiplism	0.30*	.03	
Child Absolutism	-0.27*	12	
			Nagelkerke R^2= .268*

Note. B represents unstandardized regression weights. *R* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Table 13.5

Summary of Theoretical Model for Overconfident Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	1.30		
Age	-0.08^{+}	.001	
Parent Absolutism	0.01	.001	
Parent Need for Cognition	0.00	.01	
Parent Authoritarianism	-0.05	.02	
Child Absolutism	0.12*	.001	
EF (MEFS)	-0.00	.002	
			Nagelkerke R^2 = .200

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

The best fitting model for children's Overconfident Composite Score featured child

age, parent multiplism, children's executive functioning, and children's absolutism. It suggests that children who preferred the Overconfident speaker tended to be younger, have lower EF skills, made more absolutist judgments, and had parents who made more multiplist judgments.

Table 13.6

Summary of Best Fitting Model for Overconfident Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	1.44		
Age	-0.38**	.002	
Parent Multiplism	-0.30**	.01	
EF (MEFS)	-0.26*	.01	
Child Absolutism	0.12^{+}	.02	
			Nagelkerke R^2 = .321*

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Examining children's preference for both speakers—or perhaps their lack of a preference for either—the theoretical model again included parent factors (multiplism, need for cognition, authoritarianism) as well as children's personal (age, multiplism) and cognitive factors (EF, IQ). The overall model accounted for about 21% of children's preference for both speakers, with parent need for cognition and children's executive functioning being significant predictors.

The best fitting model for children's Both Composite Score explained about 36% of the variance in children's preferences both speakers. It featured children's engagement during the intervention, parent evaluativism, and parent need for cognition as significant predictors, as well as children's executive functioning as a marginally significant

predictor. The model suggests that children who preferred both speakers tended to have lower EF skills, were less engaged later in the intervention phase, had parents who made more multiplist judgments, and had parents with a relatively low need for cognition.

Table 13.7

Summary of Theoretical Model for Both Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	0.54		
Age	-0.14	.01	
Parent Multiplism	0.04	.003	
Need for Cognition	-0.01**	.01	
Parent Authoritarianism	-0.10	.02	
EF (MEFS)	-0.01*	.001	
Child Multiplism	0.05	.02	
			Nagelkerke R^2 = .209

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Table 13.8

Summary of Best Fitting Model for Both Composite Score (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	0.15		
Engagement Score	-0.62**	.02	
Parent Multiplism	0.07*	.02	
Parent Need for Cognition	-0.01*	.01	
EF (MEFS)	-0.01^{+}	.02	
			Nagelkerke R^2 = .362**

Note. b represents unstandardized regression weights. *r* represents the zero-order correlation.
* indicates $p < .05$. ** indicates $p < .01$.

Interim Summary

Thus far, we have established that individual differences in children's judgments of speakers on the basis of their calibration are linked to individual differences in cognitive factors, epistemological beliefs, parents' epistemological and cognitive factors, and in the case of children's own calibration, even parent education (Table 13.9). Interestingly, children's preferences for the Calibrator and Overconfident speaker were explained by opposite patterns of factors. While children's preference for the Calibrator was positively associated with age, EF skills, and parent multiplism, these were all negatively associated with a preference for the Overconfident speaker. Furthermore, while children's preference for the Calibrator was negatively associated with their tendency to make Absolutist judgments, the reverse was true for children with a preference for the Overconfident speaker.

Like children who preferred the Overconfident speaker, those who did not have a preference for either speaker (choosing "both") tended to have lower EF scores. However, unlike children with a preference for the Overconfident speaker, the parents of children who chose "both" tended to make more Multiplist Judgments. Two additional factors were found to be negatively predictive of children's preference for "both": child engagement later in the intervention phase, and parent need for cognition. That is, children who indicated "both" speakers had the "best way of thinking", "knew more", and were more "likeable" would go on to be more resistant to experimenter suggestions during the intervention phase, and their parents tended to be less interested in engaging in effortful thinking and problem-solving.

Table 13.9

Summary of Significant Predictors of Individual Differences in Children's Speaker Judgments

	Age	EF	Engagement	Absolutism	Multiplism	Evaluativism	N4C
Calibrator	+	+		**Child: -**	**Parent: +**		
Overconfident	**-**	**-**		**Child: +**	**Parent: -**		
Both		**-**	**-**		**Parent: +**		**-**

Chapter 14: Individual Differences in Epistemological Stance

Absolutist Epistemology at Baseline

A mixed-effects binary logistic regression model was the best fitting model of child Absolutism, explaining about 33% of the variance (Table 14.1). This model included contextual factors (Vignette Type), parent factors (Absolutism, Authoritarianism), child personal factors (age), and cognitive factors (EF).

Table 14.1

Best Fitting Model of Children's Absolutist Judgments at Baseline by Vignette

Predictor	*b*	*SE*	Fit
(Intercept)	17.87	0.002	
Integrated	-1.48**	0.002	
Subjective	-6.74***	0.002	
Age	-3.08***	0.002	
EF (MEFS)	-1.14**	0.001	
Parent Absolutism	9.99***	0.012	
Parent Authoritarianism	4.59***	0.002	
MEFS: Integrated	.09**	0.002	
MEFS: Subjective	.004	0.002	
			R^2 = .44

Note. b represents unstandardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

As already established, children were significantly more likely to make absolutist judgments in the objective domain, and significantly less likely in the integrated and subjective domains. Children who made more Absolutist Judgments also tended to be younger and had relatively weak EF skills. Their parents were more likely to make Absolutist Judgments and have Authoritarian values. Furthermore, there was a significant

MEFS-by-Vignette Type interaction effect (Figure 14.1), such that the negative effect of EF skills on Absolutist Judgments was strongest in the Objective domain, and significantly weaker in the Integrated domains. There was no significant effect of EF on Absolutism in the Subjective domain. Thus, children with higher EF skills were significantly less likely to make absolutist judgments in the Objective vignette, EF made no difference on absolutist judgments in the Subjective domain. Furthermore, EF had a significant but small effect on absolutism in the Integrated domain.

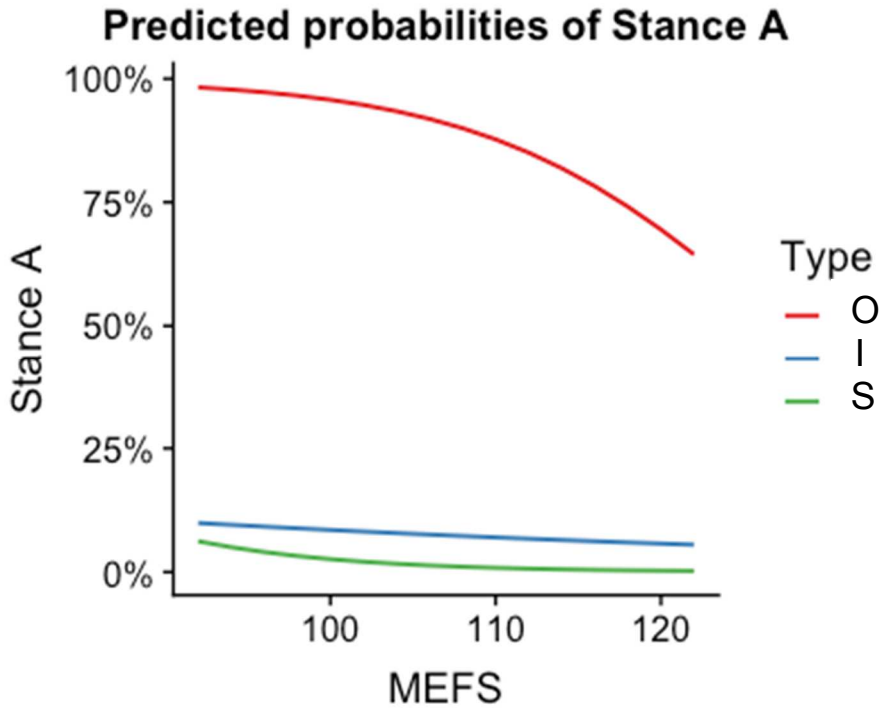

Figure 14. 1. There was a significant EF by Vignette Type Interaction Effect on Children's Absolutist Judgments at Baseline.

Multiplist Epistemology at Baseline

A mixed-effects binary logistic regression model was also conducted to understand individual differences in children's multiplist epistemology, and it was found to explain

about 16% of the variance (Table 14.2). Predictors included vignette type, cognitive factors (EF), parent factors (absolutism, authoritarianism) as well as children's age. The model indicated that children who made more multiplist judgments tended to be older and have less absolutist parents. Furthermore, as already established, children were more likely to make multplist judgments in the Objective domain, and more likely to do so in the Subjective domain.

Table 14.2

Best Fitting Model of Children's Multiplist Judgments by Vignette

Predictor	*b*	*SE*	Fit
(Intercept)	15.25^{**}		
Age	0.73^{+}	.004	
Objective	-2.7^{*}	.03	
Subjective	1.34^{**}	.001	
Parent Absolutism	-0.25^{+}	.05	
			Nagelkerke R^2 = .16

Note. b represents unstandardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

Evaluativist Epistemology at Baseline

A mixed-effects binary logistic regression model was also conducted to understand individual differences in children's evaluativist epistemology, and it was found to explain about 24% of the variance (Table 14.3). It featured parent education, Vignette Type, and Parent Absolutism interaction as predictors. Children whose parent(s) had not attained a Bachelor's degree or higher were significantly less likely to make Evaluativist judgments at baseline. Furthermore, parent absolutism was significantly negatively predictive of evaluativist judgments.

Table 14.3

Summary of Best Fitting Regression Model for Child Evaluativism at Baseline (N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)			
Parent Absolutism	-1.54**	0.74	
Parent Education	-0.9**	0.04	
			Nagelkerke R^2 = .26

Note. b represents unstandardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

Interim Summary

Thus far, we have established that individual differences in children's epistemological beliefs are linked to a number of individual differences in cognitive factors, epistemological beliefs, parents' epistemological understanding, and vignette type (Table 14.4).

Children tended to display an absolutist epistemological understanding most often in the Objective Vignette, and least commonly in the subjective domain. Children who tended to make more absolutist judgments were relatively young, were had relatively less educated parents, and had relatively authoritarian parents, and relatively absolutist judgments. Furthermore, children with weaker executive functioning skills were more likely to have absolutist beliefs, especially regarding matters of resolvable fact. That is, children's executive functioning skills acted as a moderator, amplifying the effects of vignette type.

Children tended to display a multiplist epistemological understanding most often in the subjective domain, and least commonly in the objective domain. Furthermore,

children who tended to make more multiplist judgments were relatively older, and their parents were less likely to display absolutist epistemological understanding. Finally, children who tended to display more evaluativist epistemological understanding had parents who were less likely to make absolutist judgments, and less likely to have a parent with a doctoral degree.

Notably, parent absolutism appeared as a common thread explaining children's epistemological understanding, being positively associated with children's own absolutism, but negatively associated with judgments in which the subjective dimension of knowing is acknowledged (Integrated and Subjective domains).

Table 14.4

Summary of Significant Parent (P) and Child (C) Factors Predictive of Individual Differences in Children's Speaker Judgments (N=54)

	Age	Absolutism	Education	Vignette Type	MEFS	Authoritarianism
Absolutist	**-**	**P: +**	**-**	**O: +** **I: -** **S: -**	**-** **I: -** **O: -**	+
Multiplist	+	**P: -**		**O: -** **S: +**		
Evaluativist		**P: -**	+			

Chapter 15: Individual Differences in Effects of Intervention on Target Variables

For each target variable, a "Delta" score was calculated representing the difference between the number of children's responses at baseline and the posttest. Although there was no overall effect of the intervention in the posttest, perhaps a subset of individuals did benefit. Here we examine which, if any, set of predictors explain differences in children's responsiveness to the intervention.

Table 15.1

Best Fitting Model for Change in Children's Calibration (Pre vs. Post; N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	3.51**	1.24	
Baseline Calibration Score	0.63**	.14	
Age	-0.64**	.17	
Parent Multiplism	-1.20+	.69	
Parent Multiplism: MEFS	0.11+	.01	
			Nagelkerke R^2 = .419**

Note. b represents unstandardized regression weights. * indicates $p < .05$. ** indicates $p < .01$. * indicates $p < .05$. ** indicates $p < .01$.

Calibration. The best fitting model for changes in children's calibration explained about 42% of the variance in children's Calibration Delta Score. The model included children's baseline calibration score, age, parent multiplism, and a parent multiplism-by-child EF interaction effect. It suggests that children's Baseline Calibration Score is significantly predictive of their Calibration Delta Score, such that children who were relatively strong calibrators to begin with were more likely to show further improvements. Furthermore, it indicates that younger children were more likely to show

improvements in their calibration to statistical evidence as a result of the intervention. Overall, children whose parents tended to make multiplist judgments were less likely to show improvements in their calibration as a result of the intervention. However, the significant parent multiplism-by-child EF interaction effect indicates that among children with more multiplistic parents, those with stronger executive functioning skills were more likely show improvements in Calibration.

Table 15.2

Best Fitting Model for Change in Judgments of Calibrator (Pre vs. Post; N = 54)

Predictor	*b*	*SE*	Fit
(Intercept)	0.25	.20	
Composite C	-0.49**	.13	
Baseline Calibration Score	-0.89*	.47	
Baseline Calibration Score: MEFS	0.01+	.004	
			Nagelkerke R^2 = .266**

Note. b represents unstandardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

Judgments of Calibrator. The best fitting model included children's baseline composite score for the calibrator, cognitive factors (MEFS), and personal factors (age, engagement, calibration). As expected, children's Composite Score of Calibrator Preference at Baseline was significantly negatively predictive of children's post-intervention increase in Calibrator Preference (ceiling effect). Furthermore, the model indicates that children who were poorly calibrated at baseline showed significant improvements in their judgments of the Calibrator. Finally, there was a marginally significant Calibration Score-by-EF interaction, such that children who were relatively

well-calibrated were more likely to show an improvement in their Calibrator judgments if they had stronger EF skills. That is, children who already had relevant competencies—calibration and cognitive control—benefited more from the epistemological intervention than their peers in a critical thinking context.

Evaluativist Judgments. The model that best fit the data (about 47% of the variance explained) featured parent absolutism, children's MEFS scores (EF), children's evaluativism at baseline, children's calibration score at baseline, and children's tendency to indicate they were "very" sure (an index of overconfidence rather than generally poor calibration). Furthermore, two factors in this model individually accounted for a significant amount of the variance in children's change in evaluativism: children's tendency to be "very sure" in the calibration trials at baseline, and their evaluativist tendencies at baseline. Specifically, children who tended to say they were "very sure" about their predictions were more likely to show an increase in evaluativist judgments as a result of the intervention, and children who originally made more evaluativist judgments were unsurprisingly less likely to benefit from the intervention (ceiling effect).

Table 15.3

Summary of Best Fitting Regression Model for Change in Evaluativism (N = 54)

Variable	*Standardized B*	*SE*	*Sig.*
Child "Very Sure" at Baseline*	0.294	0.230	0.016
Child Evaluativism at Baseline**	-0.680	0.076	0.001
		Nagelkerke R^2=0.469**	

*$p < .05$. **$p < .01$.

Interim Summary.

Thus far, we have established that individual differences in children's responsiveness to the intervention are linked to a number of cognitive factors, epistemological beliefs, parents' epistemological understanding, and more (Table 15.3).

Children's own ability to adjust the certainty of their predictions was more likely to improve post-intervention if they were relatively young, their parents were less likely to display multiplist epistemological understanding, and if their parents *were* relatively multiplistic they had stronger executive functioning skills.

Children's increased preference for the Calibrator overall was significantly negatively related to the Baseline Calibration Score; that is children who were relatively poor calibrators at baseline were more likely to show an increased preference for the Calibrator after the intervention. Furthermore, children who were relatively good calibrators and had strong EF skills showed an improved ability to preferentially indicate that the Calibrator was the more competent reasoner after the intervention. Finally, children who were already relatively discriminating in their preference for the Calibrator at baseline were more likely to show an increased preference for this speaker at posttest.

Finally, children's ability to recognize the integrated objective and subjective nature of knowledge—that is, display an evaluativist epistemological understanding—at baseline was significantly negatively predictive of their improved epistemological understanding. Put differently, children who were less evaluativist at baseline were more likely to increase their evaluativist judgments after the intervention, likely because they had the most "room for improvement". Children who were overconfident in their

predictions—that is, they tended to say they were "Very Sure" the box would light up—were also more likely to display an increase their evaluativist reasoning after the intervention.

Table 15.4

Summary of Significant Parent (P) and Child (C) Factors Predictive of Individual Differences in Children's Responses to the Intervention (N=54)

	Age	MEFS	Multiplist EU at Baseline	Evaluativist EU at Baseline	Baseline Calibration Skills	"Very Sure" at Baseline	Baseline Calibrator Preference
ΔCalibration Skills	**-**	**Parent Multiplism* EF: +**	**P: -**		+		
Δ Calibrator Preference		**Baseline Calibration* EF: +**			**-**		+
ΔEvaluativist EU				**-**		+	

Part IV: Discussion

As reviewed, this work represents an opportunity to address four major gaps in the literature on personal epistemology: 1) the study of *epistemological understanding and critical thinking in children as young as six;* 2) the lack of experimental work on *causal mechanisms of epistemological development*, particularly those that pertain to everyday social experiences (e.g. conversations with parents or teachers); 3) the lack of study designs that allow for causal inferences about *effects of epistemological perspectives on learning and critical thinking*; 4) the limited *examination of third variables* that could partially or completely account for the predictive relations between personal epistemology and learning (e.g. executive functioning).

Chapter 16: Early Epistemological Understanding

Baseline phase findings indicate that there is considerable inter- and intra-individual variation in 6- and 7-year-olds' philosophies of knowledge, which are reflective of context, cognitive skills, and parents' epistemological values. Children's responses to specific questions during the vignette-centered interview suggest that children are aware of, and understand, the existence of diverging perspectives. Furthermore, a majority of children recognized that the disagreement was regarding a matter of knowable truth, and about a third of the time they recognized that differences in people's ability to construct or access knowledge could explain diverging perceptions of truth.

Children also displayed sensitivity to the relatively objective or subjective nature of the disagreement in their suggested means to "figure it out". For example, children were particularly likely to suggest asking an expert in the Objective domain, and indicated that this would lead to certain knowledge at rates significantly greater than chance. Finally, children's epistemological stance was determined by their recognition of the subjective, objective or integrated nature of knowledge. As a group, children adjusted their epistemological stance—coded holistically based on their body of responses and explanations—depending on the vignette: absolutism was significantly more prevalent in the objective domain, multiplism was most common in the subjective domain, and evaluativism in the mixed domain. This is fitting, as Absolutist epistemology involves recognition of the objective dimension of knowledge and rejection of the subjective dimension, and would therefore be "easiest" to apply to matters of resolvable fact.

Similarly, Multiplist epistemology is the recognition of the subjective dimension of knowledge and rejection of the objective dimension, and would be "easiest" to apply to matters of opinion or personal taste. Similarly, the integrated vignettes would be the "easiest" to apply Evaluativist thinking to.

Importantly, these findings indicate that children not only have a rich and diverse set of epistemological beliefs and reasoning, but are also capable of far more sophisticated and flexible EU than they have been credited for in most theoretical models (e.g. Kuhn, et al, 2000; KS Kitchener & King, 1981). Rather than behave as strict objectivists, most children acknowledged the subjective dimension of knowing in at least one vignette. Impressively, nearly 40% of children held evaluativist perspectives in the subjective domain, despite work indicating that even adults struggle to acknowledge how matters of taste can be evaluated based on some objective criteria (e.g. judging music based on pitch; Kuhn, et al. 2000).

Chapter 17: Early Critical Thinking

Children were presented with two speakers who were asked to make predictions about the causal efficacy of an item after observing the efficacy of four items from the same set. One speaker, the Calibrator, adjusted the certainty of her predictions in correspondence with the strength of the data: with ambiguous data (50% effective), she was appropriately "not so sure", but with deterministic data (100% effective) she was "very sure". In contrast, the Overconfident speaker was always "very sure" of her predictions regardless of the evidence. This was a particularly challenging task given that unlike previous studies on calibration (e.g. Tenney, et al., 2011), children had no information about the accuracy of each informant's predictions. Thus, they could only rely on their tracking of the data, speaker statements, and the correspondence between these to make their judgments.

Despite these challenges, most children did discriminate between the speakers, significantly favoring the Calibrator compared to the Overconfident speaker, and marginally significantly favoring the Calibrator over "Both". Due to the low rate of errors in recalling events, these preferences cannot be attributed to children's inattention, misunderstanding, or memory of events. This replicates previous findings suggesting that 6- and 7-year-old's evaluations of reasoners are reflective of individual differences in their epistemological perspectives, and those of their parents (Suárez & Koenig, in press; Suárez & Koenig, in prep). Here, we were able to extend these findings by examining how an explicit measure of children's EU maps onto individual differences in their evaluations of reasoners, as well as establish that the predictive relation between parent

and child EU *was not* explained solely by individual differences in children's verbal intelligence or executive functioning skills.

Chapter 18: Causal Mechanisms in Epistemological Development

Here, we hypothesized that EU develops in part due to exposure to parents' own epistemological beliefs and reasoning, as well as epistemological "scaffolding" that parents may provide. Thus, the experimental treatment here consisted of a dyadic interaction with the experimenter in which: (1) evaluativist expressions were made by the experimenter and encouraged in children; (2) children were provided with opportunities to consider *both the* subjectivity and objectivity of knowledge; (3) children were asked to generate ideas about how various types of claims may be constructed or justified, and evaluate the quality and certainty of resulting knowledge as a scientist would; (4) children were encouraged to consider ways in which diverging perspectives can be reconciled, evaluated, and validated as a scientist would.

During the intervention phase, children were significantly more likely to reason about the nature of knowledge in an evaluativist fashion, and significantly less likely to express absolutist or multiplist perspectives. Thus, this intervention was effective *in real time* as a way to support the emergence of more sophisticated epistemological thought. Furthermore, at posttest, when children were asked if the disagreements in the vignettes "made sense" they were significantly less likely to say "yes", and significantly more likely to say that they "maybe". Thus, the intervention caused children to become increasingly ambivalent about whether it "makes sense" to offer two conflicting claims. Furthermore, the intervention resulted in children being more likely to recognize that the characters in the vignettes would benefit from help "figuring it out", suggesting that exposure to the epistemological scaffolding made them more aware of the resolvable

nature of the epistemological conflict. Strikingly, after the intervention children who scored relatively high on the measure of verbal IQ were also more likely to recognize that conflicting claims could simultaneously have some validity or truth value, with one being "more right" than the other.

Thus, children did become more evaluativist in their valuing of the need to justify claims, recognition that claims can be evaluated based on their relative merits, and perhaps even their comfort with recognizing the ambiguity inherent in disagreement. However, as a group, children's epistemological stance (determined using their body of responses—and explanations behind their responses) was unchanged, as pre-and post-test measures of epistemological beliefs were not significantly different.

Despite this, there were children who benefitted more than others from the epistemological intervention, suggesting that there were carry-over effects to the posttest for some children. Notably, children who became more evaluativist at posttest were significantly more likely to be overconfident in their causal predictions, and significantly less likely to have made evaluativist judgments at pretest; thus, this intervention was successful for children who were more "in need" of it.

However, the effects of the intervention on children's calibration and evaluations thereof were not necessarily beneficial. Despite changes in the frequency of "very sure" and "not so sure" responses, the children's calibration scores were not significantly different after the intervention, indicating that although children were generally less certain in the posttest, they were not better calibrated. That is, their uncertainty was not solely in the face of ambiguous statistical data. Furthermore, after the intervention

children were more likely to say that "both" speakers had the best way of thinking. Thus, it seems that children were generally less confident and discriminating in their social learning as a result of the intervention.

Put together, these results do support the conclusion that interacting with an adult in an epistemologically supportive way does lead to modest changes in their epistemological understanding and critical thinking. However, many questions remain unanswered and should be addressed in the future. First, it is not clear which aspect(s) of the epistemological intervention drove these changes. Second, this interaction was intensive and short-term; how well do these results represent effects of the brief and continuous long-term exposure to epistemological conversation children receive every day from parents and teachers? Third, if EU supports critical thinking, why did the epistemological intervention lead to an increase in children's preference for "both" (or neither)? Fourth, what is breadth and duration of the intervention's effects on children's EU and critical thinking? Fifth, how effective would this intervention be with children of different ages or backgrounds? Finally, what other everyday experiences might drive the development of children's epistemological understanding?

Examining "Third Variables"

A small but growing number of studies have indicated that there is a predictive relation between parents' and children's personal epistemology (Luce, Callanan, & Smilovic, 2013), as well as between parent epistemology and children's critical thinking (Suárez & Koenig, in press). However, these studies do not examine possible third variables that could partially or completely account for the predictive relations observed.

In contrast, the current study provides insight into whether two likely candidates--children's verbal intelligence and executive functioning—may play a role. Moreover, the study examines demographics, parent authoritarianism and need for cognition as possible moderators or mediators in this relation.

Individual differences in EU at Baseline. Children who tended to make more absolutist judgments were relatively young, had weaker EF skills, and had relatively absolutist and authoritarian parents. Furthermore, children with stronger executive functioning skills were particularly unlikely to hold absolutist beliefs in the Objective domain compared to children with weaker EF skills. This is in line with the idea that it is "easier" to have Absolutist beliefs about resolvable matters of fact, and that it takes more cognitive control to acknowledge the role of interpretation or opinion when considering these issues. likely to have absolutist beliefs if their parents also did so. Children who made more Multiplist judgments at baseline tended to be older and have less absolutist parents. Furthermore, these judgments were significantly less common in the Objective domain, and significantly more common in the Subjective domain.

However, these findings also do not offer evidence of a moderating or mediating role of EF in the relation between parent and child absolutist epistemological understanding. This would suggest that although cognitive skills—specifically children's executive functions—support children's ability to depart from strict objectivism when they reason about the nature of knowledge, it does not explain observed relations between parents' and children's EU. Similarly, demographic factors—specifically parents' educational attainment—predict children's absolutist epistemology, but this does not

account for the link between parent and child EU.

In sum, cognitive and socioeconomic factors may influence children's EU, but they are not the reason why parents' and children's epistemological reasoning are similar. With that said, it remains to be seen if this would still be the case in a more socioeconomically diverse sample. Furthermore, in this context "weak" EF skills are those around the national average. It is unclear how EF skills may predict EU in more diverse samples.

Individual differences in critical thinking. Children who were relatively well-calibrated were significantly more likely to come from a household with very high educational attainment, have strong EF skills and, have relatively parents absolutist parents, and have parents with a particularly high need for cognition. This is perhaps unexpected given that this sample is less diverse than the general population both in terms of socioeconomic background and children's cognitive skills. Because parents skewed highly educated and affluent, and children's mean IQ and EF scores were ~1.5 standard deviations above the national average, it is not possible to draw conclusions about how these factors relate to calibration in more diverse children.

Children who preferred the Calibrator were generally older, had better executive functioning skills, and were also less absolutist across the three vignettes. Furthermore, their parents tended to be more multiplistic. Thus, children who reject strict objectivism, and whose parents are relatively inclined to focus on the subjective dimension of knowledge, were more likely deem a well-calibrated reasoner who is as having the "best way of thinking", "knowing more", and being more likeable compared to a consistently

overconfident speaker. Children who preferred the Overconfident speaker showed a reverse pattern of characteristics: they tended to be *younger*, have *relatively poor* executive functioning skills, have *more* absolutist beliefs, and their parents were *less* multiplistic.

Finally, children who chose "both" speakers (and therefore had no preference for either) had a profile that somewhat resembled those who preferred the Calibrator, as well as those that preferred the Overconfident speaker. That is, like children who favored the Calibrator, their parents tended to be relatively multiplistic, focusing more on the subjective dimension of knowledge. However, like children who preferred the Overconfident speaker, they tended to have poor EF skills. Furthermore, their parents tended to have a lower need for cognition, or a tendency to enjoy engaging in effortful thinking and problem-solving. Perhaps unsurprisingly, their children also seemed less interested in epistemological problem-solving: children who preferred "both" speakers would go on to be less engaged during the epistemological intervention phase. That is, they were more likely to ignore or reject an experimenter's attempts to support evaluativist reasoning about the nature of knowledge.

Together, these findings suggest that children's ability to evaluate speakers on the basis of their reasoning about evidence is predicted by *both* cognitive skills and parent factors, namely children's EF, parent multiplism, parent need for cognition, and child engagement. Therefore, although some of these "third variables" account for some of the variance in children's critical thinking, and even moderate the effects of parent EU, parent epistemological beliefs still predict children's learning preferences above and

beyond these factors. However, it should be noted again that we cannot generalize these findings to the larger population due to the relatively educated and affluent nature of this sample.

Individual differences in sensitivity to intervention. Who benefitted from the intervention? A wide range of factors were predictive of children's responsiveness to the intervention. In some cases, the intervention benefitted children who particularly needed it. For example, the children who enjoyed the most improvements in their epistemological sophistication were low in evaluativism to begin with, and overconfident in their predictions in the face of ambiguous evidence. After the intervention, children who were relatively uncalibrated at baseline were more likely to indicate that a Calibrator had "the best way of thinking", "knows more", and was more liked. Furthermore, younger children were more likely to show improvements in their calibration skills, as were children with more multiplistic parents.

However, in other respects children with strong competencies were those who benefitted most. For instance, the children whose parents were more multiplistic did show significant improvement in their calibration, but this was especially true for those with outstanding executive functioning skills. Furthermore, children who were already relatively well-calibrated were more likely to show further improvements in this skill. Similarly, children who were already inclined to indicate that the Calibrator was the more competent reasoner became even more likely to do so after the intervention. Moreover, children who were both well-calibrated and had strong EF skills were also the most likely

to increase their preference for a well-calibrated reasoner. Thus, there are some ways in which the intervention helped “the rich get richer”.

Chapter 19: Implications and Future Directions

Because children depend greatly on others to learn about the world around them, it is important that we understand the mechanisms by which they optimize their social learning. This study is significant because it provides important insights into children's understanding of knowledge and reasoning, their developing ability to think critically about others' testimony and behavior, and the specific ways in which the people in their lives may support the development of important critical thinking skills. Specifically, this work not only reinforces the existing idea that learners' epistemological understanding has important implications for their critical thinking, but also adds to the existing literature in a number of important and exciting ways.

First, it suggests that by age six children not only have an epistemological understanding, but also that it is far more flexible, sophisticated, and context-dependent than previously imagined (e.g. Kuhn et al., 2000; Mansfield & Clinchy, 2002). Furthermore, it suggests the predictive relation between parents' and children's EU is not simply explained by heritable cognitive factors like EF and IQ. Although executive functioning skills in particular appeared to be relevant to departing from absolutist thinking—especially regarding matters of resolvable fact—parent absolutist epistemology was a significant predictor of children's EU above and beyond other factors observed. Along these lines, demographic diversity—which was rather limited in this sample—did not explain the large amount of observed variability in children's or adults' epistemological understanding.

Notably, the study also addresses relations between young children's critical

thinking and their own EU, which have not yet been directly measured and compared in any published research. Like studies before it, it suggests that children's ability to evaluate speakers on the basis of their predictive reasoning skills is related to parent characteristics, including EU, authoritarianism, and need for cognition. However, it adds to this work by providing direct measures of children's EU and revealing that children's EU—their absolutist understanding in particular— is predictive of their learning preferences.

More specifically, this work suggests that children who tend to focus more on the objective dimension of knowing, see knowledge as simple and certain, and consider claims to be simply correct or incorrect (absolutists) are much more likely to deem an unjustifiably confident reasoner as more competent than a well-calibrated one. Along these lines, children who tend to depart from absolutism—acknowledging the role of subjectivity or interpretation in the construction and justification of knowledge—are more likely to appreciate a speaker who adjusts the certainty of her predictions in correspondence with observed evidence. However, this work also suggests that other factors may also be at play, as parent multiplism and need for cognition were also predictive of children's evaluations of reasoners.

These results also raise a number of important questions about the nature of epistemological development, as well as future approaches to EU interventions. Study results indicate that dyadic interaction with an adult providing epistemological scaffolding has effects in real time on children's ability to reason about the nature of knowledge, but much remains to be understood about how this works in more naturalistic

contexts, as well as in a more diverse range of children. This is particularly important when we consider that although the population studied is fairly diverse in terms of race/ethnicity, from a socioeconomic perspective they are more likely to receive quality STEM education and career opportunities than the average American child. Thus, it is important to investigate not only how best to implement highly personalized and developmentally appropriate interventions for epistemological development, but to do so in a culturally competent manner for those who would benefit most.

Finally, this work illustrates the importance of considering not just normative trends, but individual differences in development. Even in a rather homogenous sample and within a narrow age range, we found an immense amount of variability in how children (and their parents) understand the nature of knowledge and use it to think critically about reasoners'. Thus, I would argue that if we aim to truly understand the development of social learning, we must commit to study *both* general mechanisms and individual differences. Indeed, the study of individual differences can inform our understanding of general mechanisms of development, allowing us to develop theoretical frameworks that capture the complexity and nuance of studied phenomena.

Like children, the individual differences we study are themselves complex, contextually-dependent, and developing systems. Based on these perspectives, I would offer a series of recommendations for those interested in understanding individual variation in children's learning. The study of individual differences shouldn't simply consist of comparing group means (e.g. boys vs. girls). Instead, individual differences are best understood by also examining (1) within-group variability; (2) individual variability

across contexts (e.g. home, school, etc.); (3) covariation with other factors (e.g. demographics, parenting styles); (4) processes underlying variations in learning (e.g. approaching testimonial learning using low-level cues vs. mentalizing about sources); and (5) mechanisms and contexts by which these variations may emerge and develop (e.g. media consumption, dyadic interactions with parents, ToM development).

Along these lines, I would argue that achieving a complete and nuanced understanding of the optimal conditions for learning requires a consideration of fit between a learner and their learning context. Rather than operate from the assumption that there is one set of ways to promote adaptive learning outcomes, current findings indicate that "optimal conditions" for social learning will likely vary not only as a function of age, but also family background, socioeconomic status, goals, and an individual learners' idiosyncratic constellation of cognitive skills and affective factors.

One approach to move our theoretical understanding of epistemological development and social learning forward involves the mending of existing fractures in the study of epistemological understanding, both within and across the fields of developmental and educational psychology. One idea that has proven generative in educational psychology is that of "conceptual ecology", a term originally meant to describe conceptual change in cold Darwinian terms, where only the "fittest" ideas survive (Posner et al., 1982). With the onset of a "warming" trend in conceptual change research, now the term refers to learners' idiosyncratic collections of (mis)conceptions, motivations, emotions, reasoning processes, identity, and values. By situating learning within this complex and dynamic environment, researchers are better able to understand

the variability in (mis)conceptions about physics, evolution, climate change, and more (Greene, et al, 2017; Sinatra et al, 2008). For example, this lens has offered insight into the backfire effect—or the ironic strengthening of misconceptions after an attempted refutation—suggesting that when misconceptions are tied to an aspect of a learners' identity, the negative emotions stirred by refutations inhibit conceptual change (Trevors, et al., 2016).

In the developmental literature, theories of learning often focus on general empiricist or sociocultural processes without detailing how (or if) "warmer" factors like affect or motivation are involved (e.g. rational constructivism, Xu, 2012; "theory theory", Gopnik & Wellman, 1994; sociocultural theory, Miller, 2002). In contrast, educational psychology's existing models of learning and critical thinking are inconsistent in the extent to which they address mechanisms of development and sources of individual variation, particularly for young children. Moving forward, it may be helpful for developmentalists to conceptualize early social learning as contextualized within a child's developing conceptual ecology.

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Appendix

Vignettes

Objective Vignettes

Piano story: Karen and Debra are talking about the history of pianos. Karen says: "Pianos were invented 200 years ago." Debra says: "No, pianos were invented more than 300 years ago."

Weather story: Richard and Gary are hoping to have a picnic outside. They look out the window to see what the weather is like. Richard says: "Look, it is dark and raining outside! We can't go on our picnic." Gary says: "No, it is bright and sunny outside! We can go on our picnic."

Wedding story: Greg and Nate are talking about their grandparents' wedding. Greg says: Grandma and Grampa got married in the month of July. Nate says: No, Grandma and Grampa got married in the month of February.

Integrated Vignettes

Jujus story: Lisa and Deb are at the zoo. They come to a cage with an animal they've never seen before. The sign says it's a baby juju from Australia. Lisa says, "jujus would make good pets". Deb says, "no, jujus would make bad pets".

Coach story: Edward and Dennis are talking about their coach. Edward says: "Our coach is nice". Dennis says: "No, our coach is mean."

Basketball story: Randy and Scott are talking about basketball. Randy says to Scott: "I think that the Buford Banana Slugs are a bad basketball team!" Scott says: "No, I think that the Buford Banana Slugs are a good basketball team!"

Subjective Vignettes

Painting story: Frank and Raymond are looking at paintings at the art fair. Frank says: "This painting is ugly." Raymond says, "No, this painting is pretty."

Board game story: Roy and Barry are playing a board game called "Gardylog". Roy says: "This game is very boring." Barry says: "No, this game is very fun."

Movie story: Dorothy and Joan are talking about the movie they just saw. Dorothy says: "That movie was so great!" Joan says: "No, that movie was terrible!"

Vignette Questions

*Do we know whether [x]?
*Do they agree or disagree about [x]?
Why do they disagree about [x]?
*Could they disagree because they know different things?
*Could they disagree because they like different things]?
Does it make sense to disagree about [x]? How come?
Does anyone here need help figuring out [x]?
Might someone need more help than other?
What can they do to figure it out? If they did that, would they know for sure about [x]?
Does someone have to be wrong here, or could they both be right? If they can both be right, could one be more right than the other or not really?

* Question only asked during intervention phase

Calibration Video Scripts

Familiarization Phase

50% Activation

Caroline, Brittany and Taylor are sitting at a table. Caroline is in the middle with the blicket detector in front of her; Brittany and Taylor sit at either side (counterbalanced between subjects).

Caroline: Look at these blocks! *[Pulls out 4 blocks from set A and counts them]*. One, two, three, four. Have you ever seen these blocks before? *[Taylor and Brittany indicate "no"]*.
Pay attention to what happens I put them on this box, because I'm going to ask you questions later. *[Places each block separately on the toy in a slow, deliberate fashion. Only the 2nd and 3rd block appears to make the box light up]*. Two of these made the toy go!

Caroline puts the blocks aside (still visible) and takes out a new one from the same set, holding it up and making eye contact with the camera.
Caroline: See this block? Will this one make the toy light up?

[Calibrator]: Maybe. I'm *not so sure* this will make the toy light up.
[Overconfident]: Yes. I'm *very sure* this will make the toy light up.

75% Activation

Caroline, Brittany and Taylor are sitting at a table. Caroline is in the middle with the blicket detector in front of her; Brittany and Taylor sit at either side (counterbalanced between subjects).

Caroline: Look at these blocks! *[Pulls out 4 blocks from set B and counts them]*. One, two, three, four. Have you ever seen these blocks before? *[Taylor and Brittany indicate "no"]*.
Pay attention to what happens I put them on this box, because I'm going to ask you questions later. *[Places each block separately on the toy in a slow, deliberate fashion. Only the 3rd block does not appear to make the box light up]*. Three of these blocks made the toy go!

Caroline puts the blocks aside (still visible) and takes out a new one from the same set, holding it up and making eye contact with the camera.
Caroline: See this block? Will this one make the toy light up?

[Calibrator]: Maybe. I'm *kinda sure* this will make the toy light up.

[Overconfident]: Yes. I'm *very sure* this will make the toy light up.

100% Activation

Caroline, Brittany and Taylor are sitting at a table. Caroline is in the middle with the blicket detector in front of her; Brittany and Taylor sit at either side (counterbalanced between subjects).

Caroline: Look at these blocks! *[Pulls out 4 blocks from set B and counts them]*. One, two, three, four. Have you ever seen these blocks before? *[Taylor and Brittany indicate "no"]*.
Pay attention to what happens I put them on this box, because I'm going to ask you questions later. *[Places each block separately on the toy in a slow, deliberate fashion. All the blocks appear to make the box light up]*. All of these blocks made the toy go!

Caroline puts the blocks aside (still visible) and takes out a new one from the same set, holding it up and making eye contact with the camera.
Caroline: See this block? Will this one make the toy light up?

[Calibrator]: Yes. I'm *very sure* this will make the toy light up.
[Overconfident]: Yes. I'm *very sure* this will make the toy light up.

Calibration Phase Questions

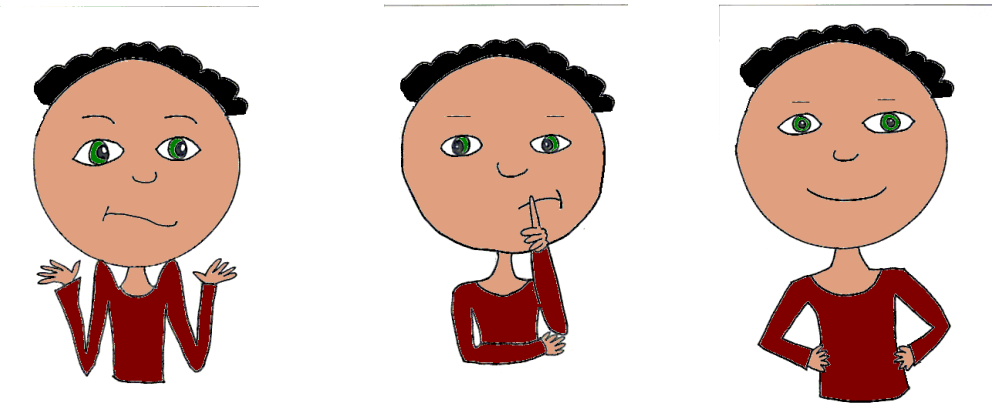
Within each trial

After Caroline demonstrates: *How many blocks made the box light up?*
After Caroline prompts prediction: *So, what do you think? How sure are you that it will make the box light up: [point to scale] very sure, kinda sure, or not so sure?*
After [Calibrator] makes a prediction: *What did [**Calibrator**] say about the block?*
After [Overconfident] makes a prediction: *What did [**Overconfident**] say about the block?*
After memory checks: *Who do you think has the best way of thinking, **[Calibrator], [Overconfident],** or both?*

After all 3 trials

Knowledge Question: *Who knows more, **[Calibrator]** or **[Overconfident]?***
Preference Question: *Who do you like more, **[Calibrator]** or **[Overconfident]?***

Certainty scale:



Demographic Survey

Dear Parents,

Your answers will be kept completely confidential, and will not be identified with your name in our records. We will not use this information for any purpose for our other than our own studies. If you prefer not to answer these questions, please check the space below (or skip the questions you'd rather not answer).

_____ I prefer not to answer these questions.

I would identify my child's sex as:

_____ Male _____ Female

I would identify my child's ethnicity as:

_____ Hispanic or Latino _____ Non-Hispanic

I would identify my child's race as:

_____ American Indian/ Alaska Native

_____ Asian

_____ Native Hawaiian or Other Pacific Islander

_____ Black or African American

_____ White

_____ Other: _____

Parent/ Guardian 1 Occupation:_____

Parent/ Guardian 2 Occupation: _____

Highest educational level (Indicate with "1" for Parent/ Guardian 1; with "2" for Parent/Guardian 2):

_____ Before high school diploma

_____ High school Diploma

_____ Some College

_____ Associate Degree (for example: AA, AS)

_____ Bachelor's Degree (for example: BA, AB, BS)

_____ Master's Degree (for example: MA, MS, MEng, MEd, MSW, MBA)

_____ Doctorate Degree (for example: PhD, EdD)

What is your total household income?

_____ Less than $19,999 _____$20,000 - $49,999 _____$50,000 - $79,999 _____$80,000 - $99,999

_____$100,000 - $139,999 _____$140,000 - $179,999 _____$180,000 - $249,999 _____$250,000 or more

Authoritarianism

Authoritarianism (1 = high authoritarian response; 0 = low authoritarian response) :

Although there are a number of qualities that people feel that children should have, every person thinks that some are more important than others. Following are pairs of desirable qualities. Please circle the one you think is more important for a child to have.

1.	INDEPENDENCE	or	RESPECT FOR ELDERS
2.	CURIOSITY	or	GOOD MANNERS
3.	OBEDIENCE	or	SELF-RELIANCE
4.	BEING CONSIDERATE	or	WELL BEHAVED

1a. 0,1
2a. 0,1
3a. 1,0
4a. 0,1

Social Conformity

Social-conformity values (1 = high value for social conformity; 0=low value for social conformity):
Next, for each of the following questions please indicate which of the two statements YOU most agree with by circling the corresponding letter (A or B):

1b. A. It's best for everyone if people try to fit in instead of acting in unusual ways. (=1)
B. People should be encouraged to express themselves in unique and possibly unusual ways. (=0)

2b. A. Obeying the rules and fitting in are signs of a strong and healthy society. (=1)
B. People who continually emphasize the need for unity will only limit creativity and hurt our society. (=0)

3b. A. We should admire people who go their own way without worrying about what others think. (=0)
B. People need to learn to fit in and get along with others. (=1)

4b. A. It is most important to give people all the freedom they need to express themselves. (=0)
B. Our society will break down if we allow people to do or say anything they want. (=1)

5. A. Society is always on the verge of disorder and lawlessness and only strict laws can prevent it. (=1)
B. It is more important to give people control over their lives than to create additional laws and regulations. (=0)

6. A. People can only develop their true potential in a fully permissive society. (=0)
B. If we give people too much freedom there will just be more and more disorder in society. (=1)

7. A. Rules are there for people to follow, not to change. (=1)
B. Society's basic rules were created by people and so can always be changed by people. (=0)

8. A. People should not try to understand how society works but just accept the way it is. (=1)
B. People should constantly try to question why things are the way they are. (=0)

9. A. People should be guided more by their feelings and less by the rules. (=0)
B. The only way to stay out of trouble is to respect the established rules of society. (=1)

10. A. People should be given the opportunity to hear all sides of a question, regardless of how controversial it is. (=0)
B. If we cannot achieve agreement on our values we will never be able to keep this society together. (=1)

11. A. In the long run our cultural and ideological differences will make us a healthier, more creative, and stronger society. (=0)
B. It is unlikely that this country will survive in the long run unless we can overcome our differences and disagreements. (=1)

12. A. Society should aim to protect citizens' right to live any way they choose. (=0)
B. It is important to enforce the community's standards of right and wrong. (=1)

13. A. Students must be encouraged to question established authorities and criticize the customs and traditions of society. (=0)
B. One of the major aims of education should be to give students a few simple rules of behavior to make them better citizens. (=1)

14. A. Young people sometimes get rebellious ideas but as they grow up they ought get over them and settle down. (=1)
B. If some people don't occasionally come up with rebellious ideas there would be less progress in the world. (=0)

15. A. It may well be that children who talk back to their parents respect them more in the long run. (=0)
B. Obedience and respect for authority are the most important virtues children should learn. (=1)

16. A. Children should be taught to do what is right even though they may not always feel like it. (=1)
B. Children should be encouraged to express themselves even though parents may not always like it. (=0)

17. A. The most important values children should learn are love and respect for their parents. (=1)
B. The most important values children should learn are independence and self-reliance. (=0)

Short Form of the Need for Cognition Scale
(Cacioppo, Petty, & Kao, 1984)

Instructions: For each of the statements below, please indicate to what extent the statement is characteristic of you. If the statement is extremely uncharacteristic of you (not at all like you) please write a "1" to the left of the question; if the statement is extremely characteristic of you (very much like you) please write a "5" next to the question. Of course, a statement may be neither extremely uncharacteristic nor extremely characteristic of you; if so, please use the number in the middle of the scale that describes the best fit. Please keep the following scale in mind as you rate each of the statements below: 1 = extremely uncharacteristic; 2 = somewhat uncharacteristic; 3 = uncertain; 4 = somewhat characteristic; 5 = extremely characteristic.

____1. I would prefer complex to simple problems.
____2. I like to have the responsibility of handling a situation that requires a lot of thinking.
____3. Thinking is not my idea of fun. a
____4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities?
____5. I try to anticipate and avoid situations where there is a likely chance I will have to think in-depth about something."
____6. I find satisfaction in deliberating hard and for long hours.
____7. I only think as hard as 1 have to. a
____8. I prefer to think about small, daily projects to long-term ones?
____9. I like tasks that require little thought once I've learned them?
____10. The idea of relying on thought to make my way to the top appeals to me.
____1 I. I really enjoy a task that involves coming up with new solutions to problems.
____12. Learning new ways to think doesn't excite me very much?
____13. I prefer my life to be filled with puzzles that I must solve.
____14. The notion of thinking abstractly is appealing to me.
____15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
____16. 1 feel relief rather than satisfaction after completing a task that required a lot of mental effort?
____17. It's enough for me that something gets the job done; I don't care how or why it works?
____18. I usually end up deliberating about issues even when they do not affect me personally.

Note. From "'The Efficient Assessment of Need for Cognition," by J. T. Cacioppo, R. E. Petty, and C. F. Kao, 1984, *Journal of Personality Assessment, 48,* pp. 306-307.
[a] Reverse scored.

Epistemic Thinking Questionnaire (Barzilai & Weinstock, 2015)

Please read the following scenarios and choose the answer that best matches your views.

History Scenario: The Fifth Livian War

North and South Livia are two small countries that existed in the nineteenth century in Central Asia. During the latter part of the century there were a series of conflicts between the two countries, termed the Livian wars. The following are two brief accounts of the Fifth Livian war, which took place in 1878. These accounts are based on actual historical events.

A brief account of the Fifth Livian war by J. Abman, expert historian of the Livian wars

In recent years a large collection of important documents from the period of the Fifth Livian war was found. On July 19th 1878, during a period set aside by North Livia to honor one of their national leaders, the ceremonies were interrupted by a sneak attack from the South Livians, beginning the Fifth Livian war. Because the North Livians were caught by surprise, they were unprepared at first and the South Livians won a few early battles. But then the tide turned heavily in favor the North Livians. Before the North Livians could reach a final victory, however, a neighboring large country intervened to prevent further bloodshed. Despite their early setbacks, the later sweeping victories of the North Livians showed that they would have won had the fighting continued.

A brief account of the Fifth Livian war by N. Ivan, expert historian of the Livian wars

The discovery of new historical documents that have never been published is shedding a new light on the events of the Fifth Livian war. In the Fourth Livian war, North Livia had beaten South Livia, taken some of its land, and refused to leave. South Livia could no longer tolerate this situation and spent large sums of public funds to strengthen its military defenses. On July 20th 1878, the Fifth Livian war began. The war took place with rapid, dramatic victories for South Livia, resulting in great national celebration. After these dramatic victories, the South Livians suffered some minor losses. But then a neighboring large country intervened to prevent further bloodshed. Despite their later setback, the final victory of South Livia seemed assured because of its overall position of strength.

1. Is there an answer to the question of what happened in the Fifth Livian War?
    a. Eventually there will be one right answer.
    b. In principle, it is impossible to know the right answer
    c. There may be multiple right answers but they are not equally right.

2. Can there be certainty about the Fifth Livian War?
    a. Eventually one could know for certain.
    b. One could never know for certain because it is impossible to find out what

happened.

c. There is never full certainty, but it is possible to improve the degree of certainty.

3. Is it possible to find out the truth about the Fifth Livian War?
    a. With further investigation we would find out that there is one truth about the Fifth Livian War.
    b. With further investigation we would find out that truth is in the eyes of the beholder.
    c. With further investigation we would find out that there is more than one truth but that there are different degrees of truth.

4. Is there truth about the Fifth Livian War?
a. There is truth. If it is not known it is important to find it out.
b. There is no single truth and therefore there is no point in seeking the truth.
c. Truth can have many interpretations but some interpretations are better than others.

5. What should the knowledge about the Fifth Livian War be based on?
a. Only on the facts.
b. Mainly on personal points of view.
c. Mainly on interpretations of data.

6. What should the knowledge about the Fifth Livian War include?
a. Only detailed data about the topic.
b. Mainly people's opinions about the topic.
c. Mainly theories that explain the topic.

7. What should be the source of knowledge of those who study the Fifth Livian War?
a. The source of knowledge should be only in evidence that can be gathered.
b. The source of knowledge should be mainly in peoples' opinions and ideas.
c. The source of knowledge should be mainly in how people interpret the evidence that was gathered.

8. Does the answer to the Fifth Livian War depend on perspectives?
a. No. One should think about the Fifth Livian War without being influenced by personal perspectives.
b. Yes. The answer to the question depends on personal perspectives.
c. Yes. But by considering multiple perspectives one can form a balanced position.

9. How should one evaluate explanations about the Fifth Livian War?
a. The most important thing is to check if the explanation reports exact data and not opinions.
b. The most important thing is to check if the explanation matches the reader's view

of the topic.

c. The most important thing is to check if the explanation helps improve understanding of what is known about the topic.

10. What is the best way to judge different accounts about the Fifth Livian War?

a. The best way is to check if the account is based only on the facts.

b. The best way is to check which account is most reasonable according to the reader's worldview.

c. The best way is to check which interpretation best explains the available data.

11. What would a reliable explanation be regarding the Fifth Livian War?

a. A reliable explanation is one that includes detailed information without opinions mixed in.

b. A reliable explanation is one that makes sense according to the reader's personal knowledge.

c. A reliable explanation is one that is based on a theory that explains the phenomena.

Biology Scenario: **Deformed Frogs**

Across North America frogs are being found that have major physical deformities. Some frogs have deformed eyes. Others have misshapen or multiple legs-- or they are missing their legs altogether. The following are two brief accounts of why the frogs are being deformed.

A brief account of why the frogs are being deformed, by G. Agmon, biologist investigating the frogs.

North American frogs have been found with deformed legs. The deformed frogs have cysts in the area from which their legs develop. These cysts are caused by parasites. The parasites enter the tadpole early in its development and burrow into the area from which their legs develop. In order to test whether the parasites cause the deformities in the frogs, an experiment was conducted in which small plastic beads were surgically implanted into tadpoles in the location where cysts were observed in adult frogs – in the area of the body from which legs develop. Many of the frogs that developed from these tadpoles had multiple legs and feet coming out of the area in which the plastic bead was implanted. Therefore, parasites in the water are causing these deformities in the frogs.

A brief account of why the frogs are being deformed by M. Moyal, biologist investigating the frogs.

In recent years, North American frogs have been found with deformed legs and eyes. Chemicals in the water are causing deformities in the North American frogs. The chemicals in the water come in contact with the tadpoles while they are developing, and this contact causes a reaction that interferes with normal development. In order to test whether the suspected chemical was in the water, a sample of water from the area where

the frogs live was taken. A lab test revealed that the suspected chemical was indeed found in the water. In order to test whether this chemical can cause the observed deformities, the chemical was applied to normal tadpoles, and the frogs that developed had deformities similar to those observed in the North American frogs. Therefore, chemicals in the water are causing the deformities in the frogs.

1. Is there an answer to the question of what happened in the deformed frogs?
    a. Eventually there will be one right answer.
    b. In principle, it is impossible to know the right answer
    c. There may be multiple right answers but they are not equally right.

2. Can there be certainty about the deformed frogs?
    a. Eventually one could know for certain.
    b. One could never know for certain because it is impossible to find out what happened.
    c. There is never full certainty, but it is possible to improve the degree of certainty.

3. Is it possible to find out the truth about the deformed frogs?
    a. With further investigation we would find out that there is one truth about the deformed frogs.
    b. With further investigation we would find out that truth is in the eyes of the beholder.
    c. With further investigation we would find out that there is more than one truth but that there are different degrees of truth.

4. Is there truth about the deformed frogs?
a. There is truth. If it is not known it is important to find it out.
b. There is no single truth and therefore there is no point in seeking the truth.
c. Truth can have many interpretations but some interpretations are better than others.

5. What should the knowledge about the deformed frogs be based on?
a. Only on the facts.
b. Mainly on personal points of view.
c. Mainly on interpretations of data.

6. What should the knowledge about the deformed frogs include?
a. Only detailed data about the topic.
b. Mainly people's opinions about the topic.
c. Mainly theories that explain the topic.

7. What should be the source of knowledge of those who study the deformed frogs?
a. The source of knowledge should be only in evidence that can be gathered.
b. The source of knowledge should be mainly in peoples' opinions and ideas.

c. The source of knowledge should be mainly in how people interpret the evidence that was gathered.

8. Does the answer to the deformed frogs depend on perspectives?
a. No. One should think about the deformed frogs without being influenced by personal perspectives.
b. Yes. The answer to the question depends on personal perspectives.
c. Yes. But by considering multiple perspectives one can form a balanced position.

9. How should one evaluate explanations about the deformed frogs?
a. The most important thing is to check if the explanation reports exact data and not opinions.
b. The most important thing is to check if the explanation matches the reader's view of the topic.
c. The most important thing is to check if the explanation helps improve understanding of what is known about the topic.

10. What is the best way to judge different accounts about the deformed frogs?
a. The best way is to check if the account is based only on the facts.
b. The best way is to check which account is most reasonable according to the reader's worldview.
c. The best way is to check which interpretation best explains the available data.

11. What would a reliable explanation be regarding the deformed frogs?
a. A reliable explanation is one that includes detailed information without opinions mixed in.
b. A reliable explanation is one that makes sense according to the reader's personal knowledge.
c. A reliable explanation is one that is based on a theory that explains the phenomena.